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POPULAR ASTRONOMY.

PLAINLY WORDED AND LARGELY UNTECHNICAL IN LANGUAGE. AMPLY ILLUSTRATED.

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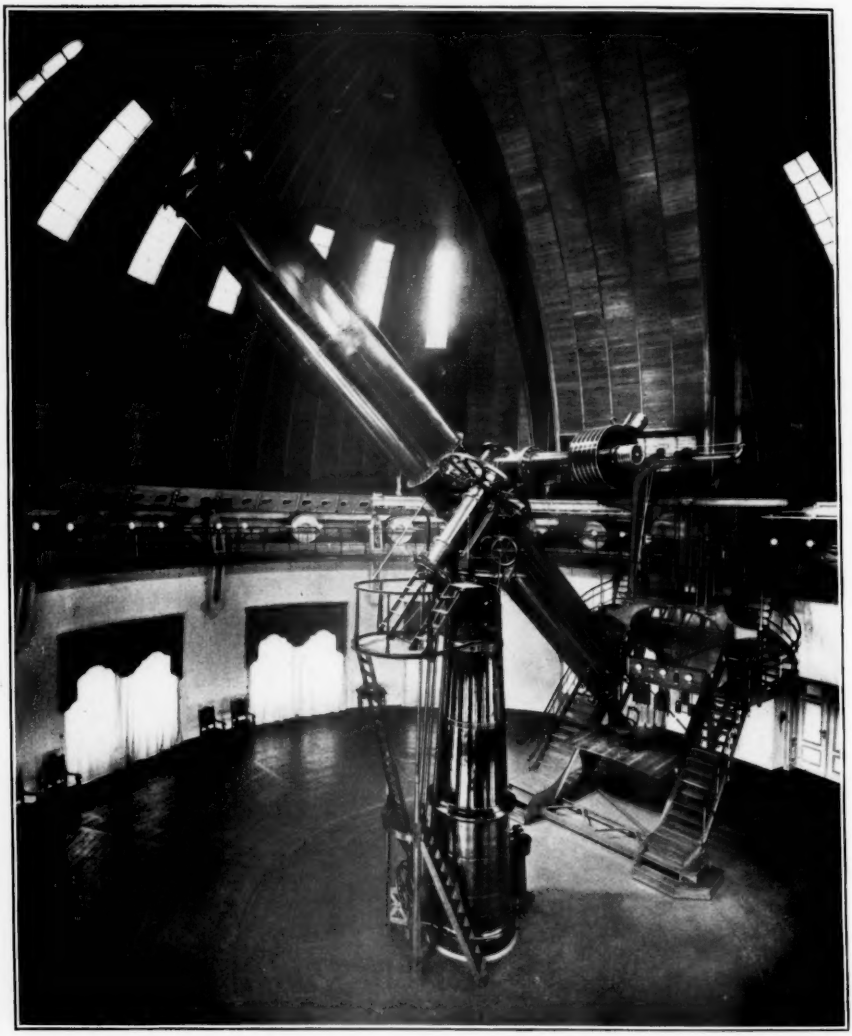
PLATE I.



THE NEW PHOTOGRAPHIC TELESCOPE OF THE ASTROPHYSICAL OBSERVATORY AT POTSDAM.

Popular Astronomy.

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A POSSIBLE EXPLANATION OF THE GEGENSCHEIN.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

Besides the Moon, we know that there must be countless much smaller bodies constantly circling about the Earth, in various directions and at various distances. Owing to collisions, and attractions of the Sun and Moon, some of these bodies are occasionally drawn from their normal orbits and precipitated upon the Earth as meteorites. Those that continue to circulate in direct closed orbits, nearly parallel to the plane of the ecliptic, must all, drawn by tides which they themselves produce, gradually recede from the Earth. When they have receded to something over one million miles their periods of revolution will be just one year, and as soon as they recede beyond that point they will be left behind by the Earth in her orbit, and lost to her as satellites. Henceforward they will be dependants upon the Sun. As they approach this limiting distance, however, their rate of recession will become slower, and accordingly a large proportion of them will be found at about this distance from the Earth, and with periods of about a year.

Any meteorite whose period is just one year will remain at a constant difference of longitude from the Sun. As its period approaches this figure it will be much perturbed of the Sun, and rapidly change its longitude with regard to it, save in one position, that where it is in line with the Earth and Sun, and beyond the former. Here the perturbations will be slight, and consequently the change of position slow, and therefore there will be a greater number of the meteorites collected in this place. In this place, moreover, since they will appear full as seen from the Earth, they will appear at their brightest.

It is therefore suggested that we have here a possible explanation of the Gegenschein, which according to this hypothesis would be an actual body attendant upon the Earth; in short, a sort of cometary or meteoric satellite. Its mass would be small, but its bulk as judged from its angular dimensions would be great, being not far from that of the planet Jupiter.

No meteorite whose period of revolution was one year could remain in line between the Sun and Earth, as it would be drawn away by the former body. There seems to be no question but that some action such as that above described must take place, and therefore that the light of the Gegenschein must be due in part, at least, to this cause, the only question is whether it is wholly due to it; in other words, whether the suggested explanation is adequate to produce the effect observed. A suggestion that the Gegenschein might be of meteoric origin was made by Professor Searle in 1882 (A. N. C II. 266).

It may be pointed out if this hypothesis is correct, that the Moon should produce some effect upon the location of the Gegenschein. Thus, when the Moon, is full the Gegenschein should be slightly to the west of its mean position, and when the Moon is new, it should be somewhat to the east of it. In an article printed for private distribution, but taken in part from POPULAR ASTRONOMY for 1897, Vol. V., p. 178, Mr. Douglass gives the results of an examination of 254 observations of the Gegenschein made chiefly by himself, and concludes that the longitude of the Gegenschein does bear a definite relation to the lunar month. He finds "that observations made before new Moon have a tendency to place the Gegenschein farther east than those made after." Should these observations be confirmed, there would seem to be no doubt that the Gegenschein is a material object attending the Earth in its orbit, and not merely an electrical discharge or a phenomenon produced by remote bodies outside of the orbit of Mars.

HARVARD COLLEGE OBSERVATORY,
December 8, 1899.

THE EULER-LAMBERT EQUATION FOR PARABOLIC MOTION.

ASAPH HALL.

FOR POPULAR ASTRONOMY.

It is well known that the important equation between the time of moving through the arc of a parabola, the two radii vectores, and the chord, was given first by Euler, although for many years it was known as Lambert's equation. This formula was published by Euler in the Memoirs of the Berlin Academy, 1743. It is given in his work on the orbit of the Comet of

March, 1742. Euler gives two demonstrations, and finds in our modern notation the known equation,

$$kt = \frac{1}{6}\left[(r+r'+c)^{\frac{3}{2}} - (r+r'-c)^{\frac{3}{2}}\right] \qquad (1)$$

He gives no plus sign to the second term, which is required when the heliocentric motion is more than 180°. Euler's method of determining the orbit of the comet is to make by trial the computed interval of time agree with the observed interval. He also tries the theory of an ellipse, assuming that the semi parameter is to the perihelion distance as $2 - \alpha$ is to 1 and finds $\alpha = 0.06047$. Euler gives this value of the perihelion distance,

$$q = \frac{(r-r'+c)\,.\,(r-r'+c)}{4\,(r+r') - 4.\left[(r+r'-c)\,(r+r'+c)\right]^{\frac{1}{2}}}$$

I do not find that Euler ever made any further use of formula (1). It appears to have been forgotten by the author, and by every one, until it was rediscovered by Lambert, and published by him in his elegant treatise, "*Insigniores orbitae Cometarum Proprietates*," 1761. In article 83 Lambert gives formula (1), with the negative sign only, as Euler had done. He expands (1) in a series according to the ratio $\frac{c}{r+r'}$: and this is the series employed by Encke for the solution of (1).

Equation (1) has been transformed in many ways. A useful method is to divide the equation by $(r+r')^{\frac{3}{2}}$, and write it in the form,

$$\frac{6kt}{(r+r')^{\frac{3}{2}}} = \left(1 + \frac{c}{r+r'}\right)^{\frac{3}{2}} - \left(1 - \frac{c}{r+r'}\right)^{\frac{3}{2}}$$

From the geometrical conditions we may always put

$$\sin\gamma = \frac{c}{r+r'},$$

taking γ less than 90°. Now it is evident that

$$\left(\cos\frac{1}{2}\gamma \pm \sin\frac{1}{2}\gamma\right)^2 = 1 \pm \sin\gamma,$$

and hence

$$\frac{6kt}{(r+r')^{\frac{3}{2}}} = \left(\cos\frac{1}{2}\gamma + \sin\frac{1}{2}\gamma\right)^3 - \left(\cos\frac{1}{2}\gamma - \sin\frac{1}{2}\gamma\right)^3$$

$$= 6\cos^2\frac{1}{2}\gamma\sin\frac{1}{2}\gamma + 2\sin^3\frac{1}{2}\gamma.$$

Or we may write

$$\frac{6kt}{\sqrt{8}.\ (r+r')^{\frac{3}{2}}} = 3\left(\frac{\cos\frac{1}{2}\gamma}{\sqrt{2}}\right) - 4\left(\frac{\sin\frac{1}{2}\gamma}{\sqrt{2}}\right)^3.$$

If therefore we put

$$\frac{6kt}{\sqrt{8}.\ (r+r')^{\frac{3}{2}}} = \sin\psi,$$

the last equation gives by the forms for the sine of a triple arc,

$$\sin\frac{1}{2}\gamma = \sin\frac{1}{3}\psi.\sqrt{2}.$$

Gauss appears to have pointed out this transformation.

CAMBRIDGE, Mass.
1899, Dec. 4th.

PHOTOGRAPHIC EFFICIENCY OF THE CROSSLEY REFLECTOR.

We have been greatly interested in the recent photographic work of Professor J. E. Keeler, Director of Lick Observatory, Mount Hamilton, Cal., which is done by the aid of the Crossley Reflector. This large reflecting telescope was originally made by Calver; it was for some time used by Dr. A. A. Common, of England, who obtained with it some excellent celestial photographs for which he received the Gold Medal of the Royal Astronomical Society in 1884. Later it came into the hands of Mr. Crossley who, after making some improvements upon it, in 1895, presented it to the Lick Observatory while Professor E. S. Holden was Director.

Last May Professor Keeler published a brief account of some photographic work by the aid of this instrument in the *Publications of the Astronomical Society of the Pacific*. That account is so instructive and so useful to any one interested in celestial photography that we give below the article in full.

By permission of Professor Keeler we are able to reproduce one of the finest photographs of Earl Rosse's wonderful spiral (M. 51), sometimes called the "Whirlpool Nebula," we have ever seen. The reproduction in our cut, though carefully done, does not equal the exquisite photograph obtained by Professor Kee-

PLATE II.

THE GREAT SPIRAL NEBULA IN CANES VENATICI.

Photographed with the Crossley Reflector of Lick Observatory.
Exposure 4 hours.

ler with the Crossley reflector. A beautiful lantern slide of that photograph was sent to Dr. Wilson, of Goodsell Observatory, only a few days ago, and our illustration was made from the lantern slide. The size of our cut is one and one-half times that of the picture which appears to be the size of the focal image of the nebula in the Crossley reflector. Of this, however, we are not sure for Professor Keeler has not yet given information on this point.

The picture of this Nebula by Mr. Roberts, of England, will be found in *Knowledge* Vol. 12, (1889) facing page 188. The Roberts' picture was taken April 21, 1889, with a 20-inch silver-on-glass reflector with an exposure of 4 hours. The print is we think by the collotype process. By reading the following account any one will readily understand the advantages which Professor Keeler would have both in size of instrument and locality for work of this kind. Mr. Roberts' picture although enlarged 8 diameters is still a little smaller than that obtained at Mount Hamilton. The enlargement of a photograph so much has undoubtedly both diminished the sharpness of detail and occasioned a loss of the fine contrast and very minute features that may appear in the original negative. The exquisitely delicate mingling of shade and the soft effect of definite color in the Keeler picture is certainly charming to those who love to study good photographic work. Professor Keeler gives reasons for these results in the following article:

"The reflecting telescope has been so little used in this country, since the time of Henry Draper, that a few notes on the photographic efficiency of the Crossley reflector may be of interest to American readers.

The Crossley dome is built on the farther end of a long rocky spur, which extends from the principal summit of Mt. Hamilton toward the south, and is within a few minutes' walk (or climb) of the main Observatory. The mirror, which has a very fine figure, has an aperture of three feet, and a focal length of seventeen feet six inches. The mounting, as compared with the beautifully mounted large refractors of the Observatory, is undoubtedly a rude piece of mechanism, but with sufficient experience of its numerous idiosyncrasies, the observer can obtain negatives with exposures of four hours' duration, with only an occasional failure.

At present the Crossley telescope is being used for photographic observations of nebulæ. For such work the summer months at Mt. Hamilton present almost ideal conditions. The

sky is continuously and often brilliantly clear, while the dryness and purity of the air are such that the silvered surfaces retain their brilliancy without any care on the part of the observer. Within the last week, however, the smoke from forest fires (from which there seems to be no escape in even the remotest corners of the Earth) has greatly dulled the brightness of the sky, and has interfered most annoyingly with the photographic work. In the winter months, on the other hand, the conditions are generally bad, on account of storms, snow, fog, or dampness; yet there are many nights, between the spells of bad weather, on which the telescope can be used.

To one who, like myself, has always worked with refracting telescopes, the photographic power of a large reflector is surprising. In this respect, the Crossley reflector does not, of course, surpass any other reflecting telescope of like dimensions, but its photographic "rapidity" is certainly very considerably greater than that of a refracting telescope of the same angular aperture. This is due to the fact that the silvered surfaces absorb less of the chemically active light than the glass lenses of a refractor, and it is noteworthy that this superiority of the reflector becomes more pronounced the finer the atmospheric conditions under which the two classes of instruments are compared. On one of the fine nights which I have mentioned, when the Milky Way shines with astonishing splendor and the whole heavens look phosphorescent, the photographic activity of the reflector is remarkably increased. But the performance of the refractor is not greatly changed, for the reason that the short light-waves, which are transmitted more abundantly by the unusually clear air, are in any case strongly absorbed by glass.

To illustrate the photographic rapidity of the Crossley telescope, I give the following examples of exposure-times in which well-known nebulæ have been photographed:—

The Ring nebula in *Lyra* has been photographed on several occasions, and the results are described in another part of the present number of the *Publications*. It will be seen that the best general representation of the nebula was obtained with an exposure of ten minutes. On this plate the stars are perfectly round and very small. The disc of the central star of the nebula has a diameter of 3″.5; that of the smallest stars shown does not exceed 1″.5. On the same plate is a double star (not resolved) the equal components of which are about 2″ apart, while their magnitude is not less than 17 or 18. It will hardly be observed visually. The central star, which has a visual mag-

nitude of 15.4, according to Burnham. gave a distinct image in one minute.

Photographs of small planetary nebulæ have been made, not only for the purpose of ascertaining the exposure-times required for such objects, but to see what amount of detail can be shown in a surface of such small dimensions. With regard to the latter purpose, it was found that a large amount of detail was shown, but that visual observation with the 36-inch refractor was more satisfactory than photographic observations with the reflector.

In the case of the small but remarkable planetary nebula G. C. 4628 (26″ x 16″), the best general picture was obtained in two minutes, while with the "ansæ," extending outward from and connected with the main nebula, were well shown in ten minutes.

Another planetary nebula which has been photographed is G. C. 4964. Eight images were obtained on the same plate by slightly changing the position of the plate-holder between the exposures, which ranged from two minutes to one second. The images which received exposures of one minute, thirty seconds, and twenty seconds respectively, were the best. A weak image, in which the central star was just visible, was produced in two seconds, and a bare trace of the nebula was visible at the place where the exposure was one second.

The planetary nebula in *Draco*, G. C. 4373, has also been photographed, with quite similar results; and small nebula discovered by Professor Barnard near the star *Merope* is distinctly shown on a negative of the *Pleiades* which was exposed for thirty seconds.

The photographic power of the reflector which is illustrated in the foregoing examples is very advantageous in the case of objects which are of very unequal brightness, as a very full light-action, and consequently softening of contrasts, is obtained with a comparatively short exposure. If, for instance a plate is exposed for ten minutes to such an object as the great cluster in *Hercules*, and rather strongly developed, a negative is obtained which shows very distinctly all the brighter stars. If the plate is exposed for two hours, and is then very lightly developed, the brighter stars appear much as before, but the swarms of minute stars, to which a globular cluster seems to owe its nebulous aspect, also appear on the plate, so that the photograph closely represents the appearance of the cluster as seen in a large telescope. On a photograph of the cluster in *Hercules*, made with

the Crossley reflector on July 13th, with an exposure of two honrs, over 5,400 stars were counted within the limits of the cluster. The average diameter of a star disc is 3″.5. A discussion of stars in the cluster, as shown by this photograph, has been made by Mr. Palmer.

With exposures of four hours, stars and nebulæ are photographed which are far beyond the range of the 36-inch refractor. On one plate (3¼ x 4¼ in.) sixteen new nebulæ were found. It would be easy with this instrument greatly to increase the number of known nebulæ; but the discovery of new nebulæ, all of which would necessarily be faint, seems to be much less important than the gain of further information about nebulæ already known. For this reason no search has been made for new objects, though a catalogue will be made in due time of those which have been found in the course of other investigations."

REPORT ON PROGRESS IN NON-EUCLIDEAN GEOMETRY.*

GEORGE BRUCE HALSTED.

"Projective Geometry proper," says Russell, "does not employ the conception of magnitude."

Now it is in metrical properties alone that non-Euclidean and Euclidean spaces differ. The distinction between Euclidean and non-Euclidean geometries so important in metrical investigations, disappears in projective geometry proper. Therefore projective geometry deals with a wider conception, a conception which includes both, and neglects the attributes in which they differ. This conception Mr. Russell calls 'a form of externality.' It follows that the assumptions of projective geometry must be the simplest expression of the indispensable requisites of all geometrical reasoning.

Any two points uniquely determine a line, *the straight*. But any two points and the straight are, in pure projective geometry, utterly indistinguishable from any other point pair and their straight. It is of the essence of *metric* geometry that two points shall completely determine a spatial *quantity, the sect* (German strecke). If Mr. Russell had used for this fundamental spatial magnitude this name, or any name but 'distance,' his exposition would have gained wonderfully in clearness. It is a misfortune to use the already overworked and often misused word 'distance'

* Continued from page 523.

as a confounding and confusing designation for a sect itself and also the measure of that sect, whether by superposition, ordinary ratio, indeterminate as depending on the choice of a unit; or by projective metrics, indeterminate as depending on the fixing of the two points to be taken as constant in the varying cross ratios.

That Mr. Russell's chapter 'A Short History of Metageometry,' contains all the stock errors in particularly irritating form, and some others peculiarly grotesque, I have pointed out in extenso, in *Science*, Vol. VI., pp. 478–491. Nevertheless the book is epoch-making. It finds "that projective geometry, which has no reference to quantity, is necessarily true of any form of externality. In metrical geometry is an empirical element, arising out of the alternatives of Euclidean and non-Euclidean space."

One of the most pleasing aspects of the universal permanent progress in all things non-Euclidean is the making accessible of the original masterpieces.

The marvellous '*Tentamen*' of Bolyai Farkas, as Appendix to which the 'Science Absolute' of Bolyai János appeared, a book so rare that except my own two copies, I know of no copy on the Western Continent, a book which has never been translated, a field which has lain fallow for sixty-five years, is now being re-issued in sumptuous quarto form by the Hungarian Academy of Sciences. The first volume appeared in 1897, edited, with sixty-three pages of notes in Latin, by König and Réthy of Budapest. Professor Réthy, whom I had the pleasure of meeting in Kolozsvár, tells me the second volume is in press, and he is working on it this summer.

Bolyai Farkas is the forerunner of Helmholtz, Riemann, Lie, though one would scarcely expect it from the poetic exaltation with which he begins his great work. "Lectori salutem! Scarce superficially imbued with the rudiments of first principles, of my own accord, without any other end, but led by internal thirst for truth, seeking its very fount, as yet a beardless youth, I laid the foundations of this 'Tentamen.'

"Only fundamental principles is it proposed here so to present, that Tyros, to whom it is not given to cross on light wings the abyss, and, pure spirits, glad of no original, to be borne up in airs scarce respirable, may, proceeding with firmer step, attain to the heights.

"You may have pronounced this a thankless task, since lofty genius, above the windings of the valleys, steps by the Alpine peaks; but truly everywhere are present gordian knots needing swords of giants. Nor for these was this written.

"Forsooth I wish the youth by my example warned, lest having attacked the labor of six thousand years, alone, they wear away life in seeking now what long ago was found. Gratefully learn first what predecessors teach, and after forethought build. Whatever of good comes, is antecedent term of an infinite series."

His analysis of space starts with the principle of continuity: spatium est quantitas, est continuum (p. 442). This Euclid had used unconsciously, or at least without specific mention; Riemann and Helmholtz consciously. Second comes what he calls the *axiom of congruence*, p. 444, § 3, "corpus idem in alio quoque loco videnti, quæstio succurrit: *num loca ejusdem diversa æquaila sint?* Intuitus ostendit, æqualia esse."

Riemann: "Setzt man voraus, dass die Körper unabhängig von Ort existieren, so ist das Krümmungsmass überall constant." See also the second hypothesis of Helmholtz.

Third, any point may be moved into any other; the free mobility of rigid bodies. If any point remains at rest any region in which it is may be moved about it in innumerable ways, and so that any point other than the one at rest may recur. If two points are fixed, motion is still possible in a specific way. Three fixed points not costraight prevent all motion (p. 446, § 5).

Thus we have the third assumption of Helmholtz, combined with his celebrated principle of Monodromy.

Bolyai Farkas deduces from these asumptions not only Euclid but the non-Euclidean systems of his son János, referring to the approximate measurements of astronomy as showing that the parallel postulate is not sufficiently in error to interfere with practice (p. 489) This is just what Riemann and Helmholtz afterward did, only by casting off also the assumption of the infinity of space they got also as a possibility for the universe an elliptic geometry, the existence of a case of which independently of parallels was first proven by Bolyai János when he proved spheries independent of Euclid's assumption. So if Sophus Lie had ever seen the 'Tentamen," he might have called his great investigation the Bolyai-Farkas Space Problem instead of the Riemann Helmholtz Space Problem.

The first volume of the 'Tentamen' as issued by the Hungarian Academy does not contain the famous appendix. But in 1897, Franz Schmidt, that heroic figure, ever the bridge between János and the world, issued at Budapest, the Latin text of the Science Absolute, with a biography of Bolyai János in Magyar, and a Magyar translation of the text by Suták József.

Strangely enough, though the Appendix had been translated into German, French, Italian, English, and even appeared in Japan, yet no Hungarian rendering had ever appeared. It was Franz Schmidt who placed the monument over the forgotten grave of János, only identified because there still lived a woman who had loved him. Now in this Magyar edition he rears a second monument. The introduction by Suták is particularly able.

The Russians have honored themselves by the great Lobachévski Prize; why does not that glorious race, the Magyars, do tardy justice to their own genius in a great Bolyai Prize?

One other noble thing the Hungarian Academy of Science has just achieved, the publication in splendid quarto form of the correspondence between Gauss and Bolyai Farkas: (Briefwechsel zwischen Carl Friedrich Gauss und Wolfgang Bolyai). It was again Franz Schmidt, who after long endeavors, at last obtained this correspondence from the Royal Society of Sciences at Göttingen, where Bolyai had sent the letters of Gauss at his death. The Correspondence is fitly edited by Schmidt and Staeckel. It gives us a romance of pure science. Gauss was the greater mathematician; Bolyai the nobler soul and truer friend. On April 10, 1816, Bolyai wrote to Gauss giving a detailed account of his son János, then fourteen years old; and unfolding a plan to send János in two years to Göttingen, to study under Gauss. He asks if Gauss will take János into his house, of course for the usual remuneration, and what János shall study meanwhile. Gauss never answered this beautiful and pregnant letter, and never wrote again for sixteen years! Had Gauss answered that letter Göttingen might now perhaps have to boast a greater than Gauss, for in sheer genius, in magnificent nerve, Bolyai János was unsurpassable, as absolute as his science of space. But instead, he joined the Austrian army, and the mighty genius which should have enriched the transactions of the greatest of learned societies with discovery after discovery in accelerating quickness, preyed instead upon itself, printing nothing but a brief two dozen pages.

Almost to accident the world owes the admirable volumes in which Staekel and Engel contribute such priceless treasures to the non-Euclidean geometry. An Italian Jesuit, P. Manganotti, discovered that one of his order, the Italian Jesuit Saccheri, had already in 1733 published a series of theorems which the world had been ascribing to Bolyai. Thereupon, in 1889, E. Beltrami published in the *Atti della reale Accademia dei Lincei*, Serie 4,

Vol. V., pp. 441-448, a note entitled 'Un Precursore italiano di Legendre e di Lobatschewski,' giving extracts from Saccheri's book which abundantly proved the claim of Manganotti.

In the same year, 1889, E. d'Ovidio, in the *Torino Atti*, XXIV., pp. 512-513, called attention to this note in another entitled, Cenno sulla Nota del prof. E. Beltrami: "Un Precursore, etc., expressing the wish that P. Manganotti would by a more ample discussion rescue Saccheri's work from unmerited oblivion. Staeckel says the thought then came to him, whether Saccheri's work were not a link in a chain of evolution, the genesis of the non-Euclidean geometry.

In 1893, at the International Mathematical Congress at Chicago, in the discussion which followed my lecture, 'Some Salient Points in the History of Non-Euclidean and Hyper-Spaces,' wherein I gave an account of Saccheri with description of his book and extracts from it, Professor Klein, who had never before heard of Saccheri, and Professor Study, of Marburg, mentioned that there had recently been brought to light an old paper of Lambert's anticipating in points the non-Euclidean geometry, and named in connection therewith Dr. Staeckel. I at once wrote to him and published in the *Bulletin of the New York Math. Soc.*, Vol. III., pp. 79-80, 1893, a note on Lambert's non-Euclidean geometry, mentioning Staeckel's purpose to republish Lambert's paper in the Abhandlungen of the Leipziger Gesellschaft der Wissenschaften. But after this, in January, 1894, Staeckel formed the plan to make of Saccheri and Lambert a book, and associating with him his friend Friedrich Engel, they gave the world in 1895, 'Die Theorie der Parallelinien, eine Urkundensammlung zur Vorgeschichte der nichteuklidischen Geometrie.' Strengthened by the universal success of this book, they planned two volumes in continuation. Staeckel takes the volume devoted to Bolyai János and his father. It is to begin with a more complete life of the two than has yet appeared, of course, from material furnished largely by Franz Schmidt.

Then follows the 'Theoria parallelarum' of Bolyai Farkas, interesting as proving that in 1804 Gauss was still under the spell of Euclid.

Then is to follow the Latin text of the immortal Appendix with a German translation. Next comes in German translation selections from the 'Tentamen.' The book concludes with the geometric part of 'Kurzer Grundriss,' the only one of the Bolyai's works printed originally in German. This volume is nearly published and may be expected in a few weeks. The volume un-

dertaken by Engel has just appeared (1899). It is a German translation of Lobachévski's first published paper (1829), 'On the Principles of Geometry,' and also of his greatest work, 'New Elements of Geometry, with Complete Theory of Parallels.' Only from the 'New Elements' can any adequate idea be obtained of the height, the breadth, the depth of a Lobachévski's achievement in the new universe of his own creation.

Of equal importance is the fact that Engel's book gives to the world at last a complete, available text-book of non-Euclidean geometry. There is no other to compare with it.

For the history of non-Euclidean geometry we have the admirable Chapter X., of Loria's pregnant work, 'Il passato ed il presente delle principali teorie geometriche.' This chapter cites about 80 authors, mostly of writings devoted to non-Euclidean geometry.

In my own 'Bibliography of hyper-space and non-Euclidean geometry,' in the *American Journal of Mathematics* (1878), I gave 81 authors and 174 titles. This, when reprinted in the Collected Works of Lobachévski (Kazan, 1886), gives 124 authors and 272 titles.

Roberto Bonola has just given in the *Bolettino di Bliografia e Storia della Scienze Matematiche* (1899), an exceedingly rich and valuable 'Bibliografia sui Fondamenti della Geometria in relazione alla Geometria Non-Euclidea,' in which he gives 353 titles.

This extraordinary output of human thought has henceforth to be reckoned with. Hereafter no one may neglect it who attempts to treat of fundamentals in geometry or philosophy.

AUSTIN, Texas, Aug. 14, 1899.

OBSERVATIONS OF THE BIELIDS OF 1899.

COMMUNICATED BY G. W. MYERS.

FOR POPULAR ASTRONOMY.

Arrangements had been made at this Observatory to observe the Andromid meteors from the 22d to the 27th of Nov., but a densely clouded sky interfered with the work until shortly after seven o'clock on the evening of the 24th, when the clouds broke and cleared away entirely in the course of half an hour. Observation was then begun by the writer, assisted during a part of the evening by two of the students in astronomy, and the following data were obtained. (The times are on the 90th standard meridian; Longitude $5^h\ 52^m\ 55^s$.)

Time of Count	Begin / End	No. of Andromids.	Number per Hour.	Remarks.
8	09 23	22	110	Sky clear. 6th magn. stars visible.
8	23 38	14	56	Sky clear.
8	38 52	12	52	Getting cloudy in the north at $8^h\ 50^m$
8	52 9 07	08	32	Sky hazy and partly cloudy.
9	07 22	08	32	Sky more than half cloudy.
9	36 10 21	28	37	Quite cloudy $9^h\ 35^m$–50^m. Fairly clear $9^h\ 50^m$–$10^h\ 10^m$. Only stars of first three magnitudes visible at $10^h\ 10^m$–20^m. Clouds becoming denser, watch was discontinued.
11	06 41	24	41	Sky clear, seeing fine.

In addition to these results may be mentioned a count of about ten minutes duration (as well as could be estimated), shortly before eight o'clock, which gave twenty meteors.

The third column of the above table shows that, in the part of the swarm encountered by the Earth between half past seven o'clock and midnight, the density decreases quite markedly. The ratio of frequency from the first and second counts or from the first and third, is nearly as two to one, while comparison of the first and last makes the ratio about three to one. It is to be noted that these four counts were made with a clear sky and good seeing in each case. The clouds rising in the north at $8^h\ 50^m$ did not interfere with the third count.

An approximate location of the radiant, from 5 carefully charted trails, gave its position at a point about 2° from γ Androm. on a line toward α Cassiop. This is for the centre of what seemed to be a diffuse area.

The magnitudes and colors of individual meteors all of which are Andromids are given in the following summary:

Magnitude—	−3	−2	−1	0	1	2	3	4	5	6
Number of Meteors—	1	1	0	2	3	14	36	33	18	10
Color—	White		Yellow		Blue					
Number of Meteors—	48		45		10					

The small number of faint meteors seen is undoubtedly due to the fact that the sky was hazy or partly cloudy during more than half the time of observation.

NOTE.—A remarkable meteor, which swept entirely across the sky, was seen at $8^h\ 30^m\ 50^s$, 90th meridian time. It started from a point in Gemini, nearly due east and about 20° above the

horizon, and, following approximately the ecliptic, disappeared when at an altitude of 20° and 10° south of west. The meteor moved quite deliberately, leaving a broad, vividly blue trail, persisting about five seconds. The head was yellow, of a magnitude estimated at about — 4, and seemed to pass quite close to the observer, so that sparks could be seen streaming back from it.

The meteor was undoubtedly a Leonid, since it came directly from that point in the horizon where Leo was about to rise.

W. C. BRENKE.

UNIVERSITY OF ILLINOIS,
Dec. 13, 1899.

THE FAILURE OF THE LEONIDS IN 1899.

W. W. PAYNE.

In the December number of the Observatory (English), page 433, a brief account appears, giving some reasons why the great shower of the Leonids which had been quite generally and confidently expected was believed to be less certain than supposed as the time of the display drew near. From this article it is learned that Dr. Johnstone Stoney as early as November 10 gave before the Royal Astronomical Society the result of further researches which made the prediction of the time for the shower less certain than the conclusions he had reached and published some seven or eight months before, in which he claimed that the shower would probably take place November 15 18^h. On Nov. 14, Dr. Stoney published a letter in the "London Times" which gave some of the reasons for a less degree of certainty in regard to the time of prediction. In as much as Dr. Stoney and Mr. Downing were largely responsible for the predictions that appeared early in the year, the letter referred to above is important, and the abstract of it which appeared in the *Observatory* is given below:

"During the great shower of 1866, the position of the point of the heavens from which the meteors appeared to diverge was very carefully observed, and this determination, combined with what Professor Newton had brought to light, enabled the late Professor J. C. Adams to make one of the most brilliant astronomical discoveries of the present century—viz., the discovery of the actual orbit within the solar system which was being traversed by

the meteors which are situated in the neighborhood of that part of the stream through which the Earth passed in 1866.

"The actual shift of the node—that is, the amount by which the meteoric orbit has moved sideways along the Earth's orbit—has had considerably more than three times its average amount in consequence of the intense perturbation to which the meteors have been subjected within the last 33 years; and this is not the only respect in which Adam's orbit has been removed from the position in which he found it in 1866. This meteoric orbit then intersected the Earth's orbit. It has since been forced away from the Earth's orbit by the disturbing action of the planets, chiefly of the great planets Jupiter and Saturn. In the position which it now occupies the Earth will pass closest to it upon next Thursday morning, at about 6 o'clock A. M.; and Adams' meteoric orbit will then be as much as 1,300,000 miles distant from the Earth's orbit, that is more than five times further off than the Moon.

"This would be quite enough to carry the stream of meteors quite clear of the Earth if that stream were a mere cylindrical stream like a thread traveling lengthwise through space. But the investigations which we have had to make have brought to light the important fact that the stream where it pierces the plane of the Earth's orbit is not like a thread but more like a long piece of strap or tape traveling forwards in the direction of its length—in other words, the stream is very much wider than it is thick. Its thickness is known, from the duration of the meteoric showers, to be about 100,000 miles; but all that is known of its width is that it is much more. We shall probably not be far wrong if we estimate it as being three or four millions of miles. This very wide and comparatively thin stream of meteors passes obliquely through the plane of the Earth's orbit, and the part of the plane through which it passes has obviously the shape of a long oval or rectangle. We know where one point in this oval is at present—namely the point spoken of above where Adams' orbit pierces the plane of the Earth's orbit—a point which, as we have seen, will be 1,300,000 miles nearer to the Sun than the position which the Earth will reach at 6 A. M. on next Thursday morning. Unfortunately we do not know the length of the longer axis of the oval section, nor its position, further than that its direction originally, that is, 17 centuries ago, lay perpendicular to the Earth's orbit, and that it has since been very slowly shifted by perturbations into a position which slopes towards a part of the Earth's orbit which the Earth will reach

sooner than 6 o'clock A. M. on Thursday morning. When the shower of this year takes place, if there is one of the great showers this year, we shall know from the time of its occurrence how much the oval section has turned out of its original position. Meanwhile we can only say that the shower is to be expected before 6 A. M. on Thursday, probably some hours earlier, and possibly, but not probably, so much earlier that the beginning of the shower may be seen from our side of the Earth before dawn on Wednesday morning, It is, however, more likely to come during the daytime or evening of Wednesday, in which case it will not be seen in England, or after 10:30 P. M. on Wednesday evening, in which case it will be visible if the weather permit."

In the last issue of this journal we gave a number of reports of observers who watched the November Leonids, with charts showing the work done. We now give considerable more space to the continuance of these reports.

LEONIDS AT NORTHFIELD, MINN.

The Astronomy class at Carleton College, Northfield, Minn., consisting of twenty members, participated in the observations of the Leonid meteors Nov. 15, 17^h to 22^h 1899. Greenwich M. T. The following table gives the times and brightness of individual meteors as observed by students.

No.	G. M. T.	Mag.	No.	G. M. T.	Mag.	No.	G. M. T.	Mag.
	h m			h m			h m	
1	16 59	3	10	19 38	4	19	20 39	2
2	18 27	1	11	19 46	3	20	21 18	1
3	18 33	1	12	19 47	2	21	21 20	1
4	19 17	3	13	20 7	1	22	21 19	1
5	19 17	2	14	20 8	1	23	21 25	3
6	19 26	4	15	20 9	2	24	21 30	2
7	19 27	4	16	20 9	2	25	21 51	2
8	19 29	3	17	20 9	2	26	22 30	2
9	19 29	1	18	20 21	2			

At no time was the sky entirely clear during the night watch. It was partly clouded or covered with haze so that it was difficult to see any meteors except for the brief time they were brightest. All trails were therefore short and correspondingly uncertain in direction. If we add to this the strong moonlight, it is at once evident how unsatisfactory the observations were.

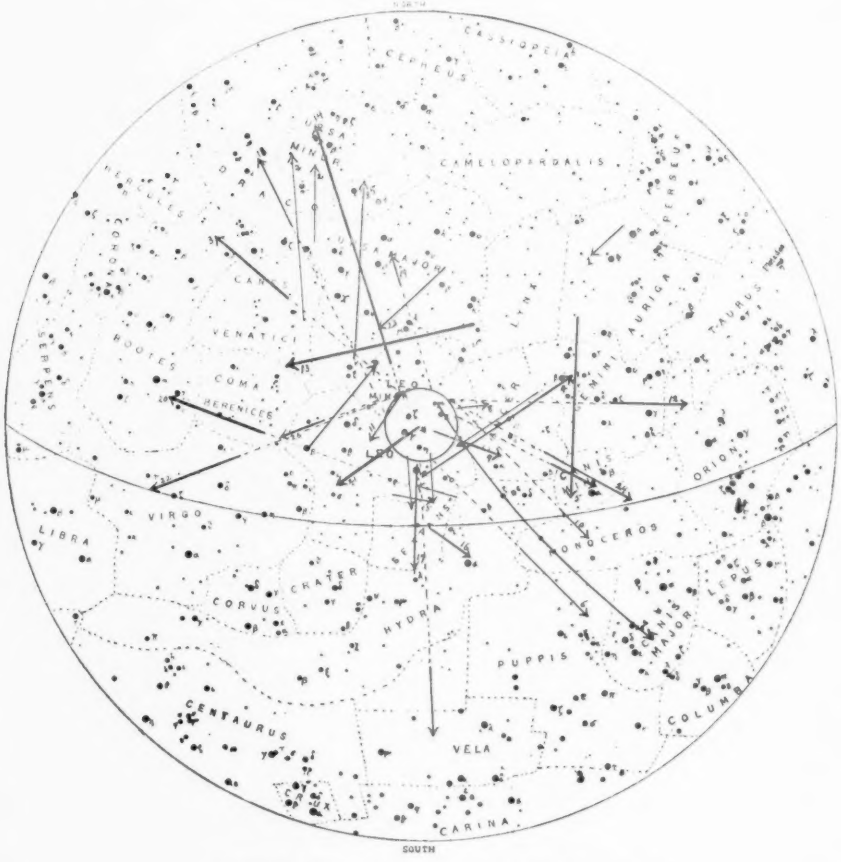
LEONIDS AT BARRE CENTER, N. Y.

On the morning of the 14th the heavens were cloudy, but on the morning of the 15th in a clear sky from 1 A. M. to 4 A. M. I charted nineteen meteors, the most of which could be traced from the Sickle in Leo, their flight was generally very rapid, with exception of two, which first appeared very near Gamma Leonis both were very bright with short trails and one of these showed a very

perceptible curve. In no case could any be said to exceed the second magnitude. At 1:30 A. M. a very large meteor far exceeding the brilliancy of Venus at her greatest with a heavy luminous train at a slow rate of motion was seen to emerge from Ursa Major and travel eastward disappearing low in the horizon. I again on the 16th and 17th at midnight resumed my watching till about four o'clock in the morning, but in neither case was a single meteor seen. I prepared to photograph the radiant with a wide angle lens and 5 x 7 plate with camera attached to my 8½ inch Brashear reflector but as no meteors were seen I abandoned the work. I enclose the chart of meteors as seen.

WESTON WETHERBEE.

BARRE CENTER, N. Y. Nov. 19, 1899.



METEORS CHARTED DURING THE LEONID SHOWER.

Nov. 15, 1899, 17^h—22^h Greenwich M. T., by students at Goodsell Observatory, Carleton College, Northfield, Minn.

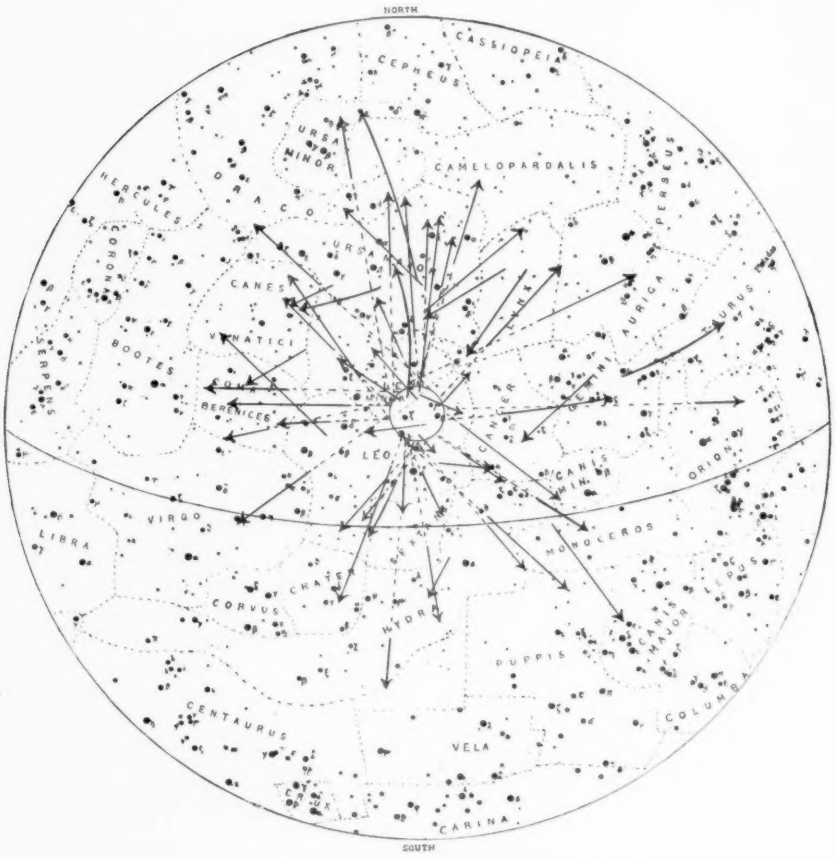
METEORS CHARTED DURING THE LEONID SHOWER.

Nov. 14, 1899, 18^h—22^h Greenwich M. T., by Mr. Weston Wetherbee at Barre Center, N. Y.

LEONIDS AT CRETE, NEB.

Observations of the Leonid meteors were made successfully from this place on the nights of Tuesday, Nov. 14, and Thursday, Nov. 16. On Monday and Wednesday nights it was cloudy as was also the case for about three hours after midnight of Thursday. No careful work was done on Friday night but a few Leonids were reported as seen by casual observers.

A considerable number of the students of Doane College volunteered their assistance for the work and the corps of observers were given detailed instruction in advance in order to secure as satisfactory results as possible. In general the suggestion of Professor Wm. H. Pickering as given in the September and October



METEORS CHARTED DURING THE LEONID SHOWER.

Nov. 14, $18^h\ 30^m$–24^h Greenwich M. T., by Professor Henry H. Hosford and students at Boswell Observatory, Doane College, Crete, Neb.

number of POPULAR ASTRONOMY were followed. It was arranged that the observers should work in sets of three. In each set one person was to keep an accurate count of all meteors seen, recording the number for each quarter hour; the second observer was to plat on the chart all meteors whose paths were accurately determined, recording the exact time when each was seen and other matters of interest; the third person was to act as time-keeper, comparing his watch each hour with the Observatory clock.

On Tuesday night for about two hours after midnight the sky was partially covered with light, filmy clouds which doubtless prevented the observers from seeing many of the less bright meteors. As the sky became clear the number of

meteors seen was much greater. The increase was especially noticeable as the Moon sank toward the western horizon and was obscured by clouds. The total number of meteors counted on Tuesday night was 198, of which 53 were platted as shown on the accompanying chart. Many are noted as showing trains persisting for a few seconds and seven were thought to follow a slightly curved path. In no case was a meteor seen to explode, to change its course abruptly or to leave a train persisting for more than a few seconds. The chart shows six meteors which were quite certainly not Leonids and as many more are doubtful.

Several photographs were taken Tuesday night by a camera mounted on the equatorial telescope but no meteor trails were shown on the plates.

The total number of meteors counted on Thursday night, Nov. 16, between 15^h and $18^h\ 30^m$ was 30. Two of these were not Leonids. Details of the count are given in the following table:

Date.	No	State of Sky.	Date.	No.	State of Sky.
Nov. 14.			Nov. 14.		
12:30-12:45	0	Hazy. Moon shining.	17:30-17:45	26	Clear.
12:45-13:00	3	"	17:45-18:00	19	"
13:00-13:15	1	"	Nov. 16.		
13:15-13:30	1	"	15:05-15:15	0	½ Cloudy. Moonlight
13:30-13:45	2	"	15:15-15:30	1	"
13:45-14:00	7	Cloudy.	15:30-15:45	1	Clearing.
14:00-14:15	6	Light haze.	15:45-16:00	1	"
14:15-14:30	9	Clear.	16:00-16:15	3	Clear.
14:30-14:45	6	"	16:15-16:30	1	"
14:45-15:00	8	"	16:30-16:45	2	"
15:00-15:15	8	"	16:45-17:00	3	"
15:15-15:30	9	"	17:00-17:15	5	"
15:30-15:45	8	"	17:15-17:30	4	"
15:45-16:00	6	"	17:30-17:45	5	"
16:00-16:15	7	"	17:45-18:00	3	"
16:15-16:30	6	"	18:00-18:15	0	"
16:30-16:45	9	"	18:15-18:30	1	"
16:45-17:00	10	" Moon setting			
17:00-17:15	21	" and clouds			
17:15-17:30	26	" in west.			

HENRY H. HOSFORD.

BOSWELL OBSERVATORY, Doane College, Crete, Nebraska.

LEONIDS AT UNIVERSITY PARK, COLORADO.

The following observations of the meteoric shower were made by the writer, except on the night of Nov. 15-16, when they were made by a corps of volunteer observers. Mountain Time was used as the standard:

Nov. 13: 12:30-13:00; no Leonids; clear.
13:30-14:00; no Leonids; clear.
14:30-15:00; one Leonid; clear.
15:30-16:00; eight Leonids; Moon has set; clear. One of the sixth magnitude glanced.
16:30-17:05; four Leonids; one faint one glanced; clear.

The average brightness was equivalent to that of a star of mag. 3 or 4.

Nov. 14: 17:00-17:35; eleven Leonids; hazy, but stars of mag. 5 were visible. Three or four were brighter than mag. 1, and no one was as faint as mag. 5. The average magnitude was 3.

17:35-18:00; four Leonids; low lying haze spread rapidly toward the zenith, and during the last five or ten minutes the stars in the Sickle were barely visible. One meteor, brighter than mag. 1, dashed across the western sky at a Leonid's pace, but its trail, which lasted perhaps two seconds, passed about five degrees above the Sickle, and it was not counted as a Leonid. The sky was cloudy before 17:00; after that there was no Moon.

Nov. 15: see below.

Nov. 16: 13:00-13:15; no Leonids; hazy so that nothing fainter than mag. 3 was visible.
13:30-13:45; no Leonids; somewhat clearer.
14:00-14:15; no Leonids; only the brightest stars visible. After this it became cloudier and observations were useless.

Nov. 17: 14:15-14:30; no Leonids; observed through a large rift in the clouds.
14:45-15:00; 1 Leonid; an area as large as I could survey was clear.
15:00-16:15; cloudy.
16:15-16:30; no Leonid; large clear area of sky.
16:45-17:00; no Leonid; sky perfectly clear in the vicinity of Leo.
17:15-17:30; no Leonid; sky cloudless.
17:45-18:00; one Leonid; sky cloudless, but light because of approaching dawn.

Nov. 16. The observers were mostly in pairs, one person observing for fifteen minutes while the others rested; the two thus kept a continuous watch upon some part of the sky. Each pair was instructed to face N., or N. E., or E., etc., and to watch a point at an altitude of 45° noting every Leonid seen, and rejecting others. The zenith was also watched by observers recumbent on a mattress. Professor E. B. T. Spencer was in charge of those counting: he rang a bell at each quarter hour, having given a warning signal two minutes previously. Below is a very condensed summary.

Mary C. Traylor and Grace M. Sater faced north and counted five between 13:00 and 15:00. Clouds then intervened. Between 15:00 and 16:15 Miss Traylor faced east and counted four.

Myron A. Pattison and Guy W. McCreery faced east and counted forty-four between 13:00 and 16:45.

Edward Stauffer and Chas. F. Seitter faced north-east and counted fifteen between 13:00 and 15:15. Clouds then came. Between 16:00 and 16:15 Mr. Stauffer counted one.

Fred Winship and Loyd Winship faced the zenith and counted three between 13:00 and 14:30. From 14:30 to 17:00 the zenith was mostly cloudly but seven were counted.

Fred Stover and Earl K. Terry faced south-east and counted sixty-four between 12:45 and 18:30, none being seen during the last fifteen minutes.

Earle Blakeslee and Wayne Blanks watched the zenith between 13:00 and 14:45 and counted six.

Bertha Brooks and Elise C. Jones faced east and counted fourteen between 13:00 and 17:00.

Daniel N Jones and Ervin N. Edgerton watched the area bounded by lines joining Rigel, Betelgeuse, Sirius and Procyon from 13:00 to 14:45 and saw two within the area.

Mr. McReynolds faced south and counted three between 14:00 and 14:15. Between 14:30 and 14:45 he saw one.

CHART OF LEONIDS DRAWN BY JAS. B. WESTHAVER.

Hazel B. Bush noted the exact times of appearance of ten of the brightest, with a stop watch.

Frank Hiller faced north and saw two between 13:00 and 14:15.

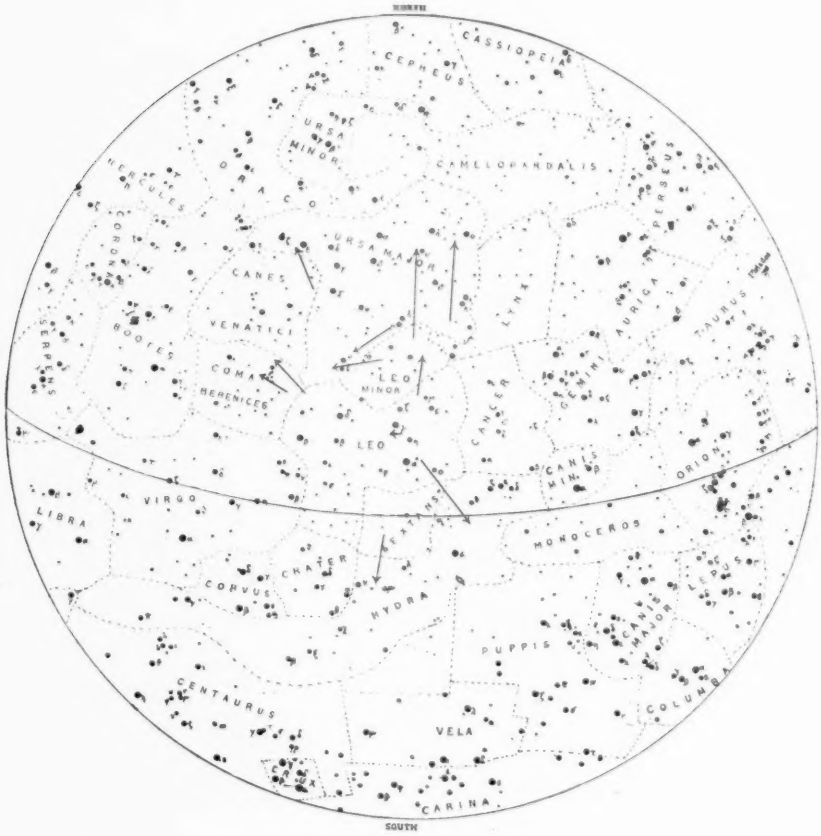
Leonora Colmer faced south-east and observed steadily from 13:30 to 16:45 excepting next to the last quarter hour; she counted thirty-three.

The radiant-point was located by a drawing by James B. Westhaver.

A study of the results shows (1) that the south-east was the most favorable direction to face, (2) that few Leonids were seen before 14^h, on any night; (3) that between 14^h and 17^h on the night of Nov. 15-16 about the same number were visible in each quarter hour, (4) that the average magnitude was about 3.5, (5) that the absence of the Moon did not materially increase the number seen, and (6) that the best time was probably not later than that predicted by Stoney and Downing, and may have been earlier. After making allowance for

probable duplicates the number seen at University Park is 180, 150 of which came on the morning of Nov. 16. For about a week prior to Nov. 13 the number of telescopic meteors seen while observing nebulae with the 20-inch refractor was about three every four hours, the field of view being 15′ in diameter. This is judged to be at least three times the ordinary frequency of such objects. But there was no evidence from their direction that they were Leonids. Has any one ever studied these telescopic objects, in order to see whether they are the residue of naked-eye meteors, or distinct minute bodies? HERBERT A. HOWE.

CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, Col.



THE LEONIDS OBSERVED AT THE ROYAL OBSERVATORY IN LISBON, PORTUGAL, Nov. 12–17, Local M. T.

OBSERVATIONS AT LISBON, PORTUGAL.

Name of observers; CR = Campus Rodrigues; O = F. Oom. **Post office address**: Royal Observatory, Tapada, Lisbon, Portugal. **Latitude** = + 38° 42′.5; **Longitude** = 36^m 45^s W. Gr.; **Time**: Local mean.

Frequency of Meteors.

Date. Observer	R.	Sky.	Began.	Ended.	No.
			h m	h m	
Nov. 12					
O.	S	Clear.	12 0	13 0	0
"	"	"	13 0	14 0	0
"	"	"	14 0	15 0	0
Nov. 13					
O.	"	Cloudy.	12 25	13 0	0
"	"	Overcoat.	13 0	13 30	—
"	"	Cloudy	14 0	14 30	0
"	"	Partly cloudy.	15 0	15 15	0
"	"	" "	16 0	16 30	0
"	"	Cloudy.	17 0	17 30	0
Nov. 14					
O.	"	Cloudy.	12 0	12 30	0
"	"	"	12 30	13 0	2
"	"	"	13 15	13 30	0
"	"	"	14 0	14 30	0
"	"	"	15 0	16 0	1
"	"	Clear.	16 0	16 25	3
"	"	Overcast.	16 30	17 0	—
"	"	Clear.	17 0	18 0	4
Nov. 15					
O.	"	Cloudy.	11 0	12 0	0
"	"	Overcast.	10 0	14 0	—
"	"	Cloudy.	14 0	15 0	0
"	"	Cloudy, hazy.	15 0	16 0	0
CR.	"	Overcast.	16 0	16 30	—
"	"	Cloudy.	17 10	17 30	8
"	"	"	17 30	17 50	1
"	"	"	17 50	18 10	1
"	"	"	18 10	18 25	1
Nov. 16					
O.	"	Overcast.	11 0	12 0	—
"	"	Cloudy.	12 0	13 0	0
"	"	Overcast.	13 0	15 0	—
CR.	"	"	16 0	19 0	—
Nov. 17					
O.	"	Clear.	12 0	13 0	0*
"	"	"	13 15	13 45	0
"	"	"	14 20	14 50	1
"	"	"	15 0	16 0	0
CR.	"	"	16 0	16 30	3
"	"	"	16 30	17 0	0
"	"	"	17 0	17 30	1
"	"	"	17 30	18 0	2

Individual Meteors.

Date. Observer	Time.	Class.	Mag.	Col.	Remarks.
	h m				
Nov. 14					
O.	12 49	1	1	w?	Trail.
"	12 56	1	1	"	Trail.
"	16 0	1	3	"	
"	16 20	n	4	"	
"	16 23	1	2	"	
"	17 30	1	3	"	
"	17 32	1	2	"	
"	17 34	1	3	"	Trail.
"	17 37	1	2	"	Trail.
Nov. 17					
O.	12 37	n	1	"	
"	14 35	1	−1	"	

* One meteor *not* Leonid: See Individual Meteors, Nov. 17, 12^h 37^m.

C. A. DE CAMPOS RODRIGUES, Director.

LISBON, TAPADA, Royal Observatory,
1899, November 25.

THE MAKING OF PHOTOGRAPHY.*

CHARLES F. HIMES PH. D., LL. D.

This hasty resumé of some of the leading facts in the growth of a branch of science, the history of which practically begins with that of the Institute, to which the occasion more naturally invited than to a display of its achievements, would find its highest justification in the enumeration of its applications. But a very few must suffice. In scientific investigation the eye has been replaced in so many cases by the camera, for observation as well as record, that we begin to inquire what is left for visual observation. This is not for the relief of the eye, but because the photographic plate has so much wider range in time and space. It is capable of observing the instantaneous, and yet of looking without wearying, but with cumulative effect by the hour to catch phenomena to which the eye, with its best aids, is hopelessly blind. It has even been said by an eminent astronomer, that it has added to observing power as much as the invention of the telescope. It has, in fact, revolutionized astronomy. Beginning with the Moon, with which perhaps least has been accomplished, total eclipses of the Sun have yielded up long desired information, otherwise unattainable, so that they, by comparison, approach the character of worked-out fields. Automatic daily observations of the solar surface, with the details of its spots, promise data for determining effects upon terrestrial climate. Nebulæ have been discovered, their form, details and conditions revealed, and fainter extensions, vaster than could be conceived, added. Comets have exhibited wonderful transformations, distortions and internal movements utterly undiscoverable by the best telescopes alone. Asteroids so numerous leave the record of their existence in trails upon the plates that, as has been said by Professor Barnard, they are turned adrift again unless they show some striking peculiarity of orbit. Meteors record their paths on which rests the expectation of precise determination of the radiant. Combined with the spectroscope, binaries of shortest periods are detected, variable stars not only discovered, but classified. The surmises of mathematicians in regard to Saturn's rings are confirmed. Runaway stars are caught. The Parisian astronomer that could

* Extract from an address Oct. 2, 1899, on the 75th anniversary of the Franklin Institute, Philadelphia, Pa.

not catch the satellite of Neptune with his telescope, could see it fixed on his photographic plate.

Photography and microscope, too, have gone hand-in hand with a more intimate sympathy even than that between the camera and telescope. Among the earliest amateurs of highest character was a large percentage of experts with the microscope. It was in the decade following the founding of the Institute that the microscope began to assume something of its present character as an instrument of delicacy and precision. In 1831, the factory of Ross was established, and under the stimulus and coöperation of such men as Herschel, Airy, Powell, and more especially Lister, improvements in the optics and mechanics of the microscope were rapidly made, so that at the discovery of photography, microscopy had an entirely modern aspect, and it recognized at once a new ally. Dr. Draper immediately took microdaguerreotypes. From this time the improvements in optical appliances urgently demanded by the microscopist were ably seconded by the photographer, and both combined were largely instrumental in occasioning the marked progress in practical optics, which, in turn, reacted to advance photography and microscopy. Even in the days of slow wet collodion good work was done with the microscope, and even stereo-photo-micrographs were taken by Professor Rood. The rapid dry-plate, sensitive to all or any desired colors, has nowhere contributed more to the advance of photographic practice than with the microscope. It has become to it only less the observing and recording eye than to the telescope. The intimate connection between the microscope and the camera is also well exemplified in the Institute, where the gifted Zentmayer gave the world its best model for the microscope, and the lens which bore his name long filled a place entirely its own in photography, and when the Government placed the administration of the total eclipse expedition of 1869 in the hands of Professor Morton, then Secretary of the Institute, it was unnecessary to seek further for the complete solution of the then new practical optical questions involved in such an enterprise.

In chemistry, Dr. Crookes, by aid of photo-spectroscopy and orthochromatic plates, has added the metal monium to the list, with its characteristic lines far out in the ultra invisible light, in the phosphorescent glow of yttria under molecular bombardment in vacuo. Meteorological science is enriched by photography. It is pertinent to mention the interesting contributions of W. N. Jennings, of the Institute, to the study of lightning dis-

charges, and the work of C. Francis Jenkins in the conversion of a scientific toy into the phantascope, which has found its extension in the kinetoscope, and which earned for him the Cresson medal of the Institute. The kinetoscope, with its miles of photographic films, as exhibited first by our H. R. Heyl, has found applications unanticipated in recording the movements during a solar eclipse and of growing plants, and has gone to the front with the army in Africa. In the industries the applications of photography are of infinite variety in character and importance. It is proposed to furnish cards for the Jacquard loom, and thus make tapestries commonplace. It will furnish water-marks for paper capable of 100,000 impressions. It reproduced the Encyclopædia Britannica at one-third the cost of type. It preserved the valuable MS. copy of Century Dictionary, which was practically uninsurable, in miniature form against loss by fire. It may, in the future, in the same way, find a place to economize shelf-room in our libraries by compressing books that are seldom or never read. Its applications are well known in the copying of inscriptions, even in dark interiors, in the preservation and duplication of valuable documents and papers, in the detection of forgeries, especially by the method of composite photography as developed by Dr. Persifor Frazer, in the furnishing of legal evidence in general, in the detection of criminals, etc. In Canada, 50,000 square miles have been platted by means of the photo-theodolite. In the late war the camera went to the front, and has furnished invaluable records. Apropos of this, it is only necessary to recall Capt. Wise making exposures while charging up San Juan Hill. In the present African war it promises to play an important part in reconnoissance through the telephoto apparatus that accompanies the British forces.

In its purely commercial aspects this subject is one of growing importance. The demands, at present great, are rapidly increasing with new applications and expansion of those now in use. Outside of the industries consuming photographic goods there are at least 1,500,000 amateurs in the United States, generally regarded as gross consumers. The industries supplying photographic wants are necessarily of the most varied character. Companies supplying them are continually increasing their plants. It is difficult to get at the amount of business and profits, but the published statement of one company originating in America, now in England and America, announced a dividend of 20 per cent. in December last, with repeated interim

dividends, on a capital of $8,000,000. Other companies show similar prosperity. One article, largely consumed, may be particularly mentioned, which America does not seem able yet to produce of best quality, namely, paper, and it is well for manufacturers to remember that in photography only the best of everything is good enough.—*Journal of the Franklin Institute*, December, 1899.

THE STUDY OF ASTRONOMY.

W. W. PAYNE.

Some time ago we were interested in finding out how generally the elements of astronomy was regularly pursued in the colleges and secondary schools of the United States. The result of a limited inquiry was, that in the colleges the study of astronomy appears very commonly in some courses and good modern textbooks have been adopted very generally. From all that could be learned, however, in regard to the way the study was taught in some colleges, there seemed to be room for improvement.

In the secondary schools the results obtained were astonishing beyond measure. We are not now prepared to make a statistical statement to support the impression on our mind made by it, but it may at present suffice to say that about one-fourth of the high schools in the United States have the study of the elements of astronomy at all in the regular courses of study now pursued. We think this statement will be borne out by a full and complete canvass of such schools in this country.

Some years ago, it was our privilege, by request of Dr. Harper, President of the University of Chicago, to sit with the committee of ten to consider and report on what requirements should be generally adopted as suitable for entrance to college in the branches of physics and astronomy. The committee of ten was made up of representative scholars and teachers of science (if the writer's name be not thought of now) from widely different parts of the United States. In the deliberations of that committee it was very soon apparent that but two members of it had any interest at all in the study of astronomy as a means of preparation to enter college and but for those two persons, it was more than probable that it would have been reported by that committee that the elements of astronomy should not be one of the requirements to enter college in any of its regular courses.

These things are mentioned that it may be known more gener-

ally what is a prevailing opinion among representative school men of the worth of this branch of study to find a place in the secondary courses of training. It is a very pertinent question for any educator to ask why this is so. These same committee men referred to above were enthusiastically interested in the study of physics and methods of teaching it in the laboratory, and they were unitedly urgent that more time should be given to this branch, even a whole year in the ordinary high school course. This condition of things could be explained by the facts that these men were teachers of elementary physics and that they had little, if anything, in later years, to do with the branch of astronomy. They did not seem to be informed in regard to the later and the better methods of teaching astronomy in secondary schools and in colleges.

In view of these facts and others like them that might be named, it is important that something should be done to put the study of the elements of astronomy in these grades of instruction on the right basis. No one says that astronomy is not one of the best and the noblest of the sciences. All believe that it should have prominent place in every college curriculum. But where it shall find place, how much time shall be given to it, and when it shall be taught are the minor points which each institution can settle for itself. But the method by which it shall be taught is common ground for all and much careful attention should be given to this side of the matter, and what we have further to say will bear on this point.

1. What ought to be done and what can be done to give elementary astronomy its proper place in courses of study for secondary schools? It is first necessary to bring to the attention of leading teachers and prominent school officers the value and place of astronomy as a disciplinary study. Those who are informed know that the advantages accruing to the student from a pursuit of this study are chiefly intellectual. The experienced teacher who can rightly advise as to the choice of studies, will never place favorable advice in the choice of astronomy as against biology or physics, on the ground that its pursuit and development will have direct bearing to enhance the material interests of mankind. It is not for a moment to be supposed that the discoveries of astronomy will at all compare in practical value with those coming to us from chemistry and electricity for uses in the arts the manufacturing industries of the world that hold so large a place in the public thought of the present time. But it is true, as Professor Young has well and thought-

fully said, that the student may expect his chief profit to be intellectual "in the widening of the range of thought and conception, in the pleasure attending the discovery of simple law working out the most complicated results, in the delight over the beauty and order revealed by the telescope in systems otherwise invisible, in the recognition of the essential unity of the material universe and of the kinship of his own mind with the infinite reason that formed all things and is immanent in them."

The five points made in this statement covering the scope of astronomy and revealing, to some extent, the unique character of the study for scholastic uses, open to view the grand possibilities of the theme. Much more could easily be said in the same line, but that is not necessary or desirable now.

2. How shall astronomy be taught? If we have rightly in mind the value of this branch as a means of training, and have given it proper place in courses of study mapped out for use, then comes the important query how shall this study be taught? As we have said in these pages more than once recently, the teaching of astronomy is now rapidly undergoing a change which is to increase its efficiency and to bring it rapidly and widely to favorable notice in public school instruction. That change is coming in the uses that are to be made of text-books. Too generally the text-book in this branch of study is made the end of the student's effort. When he has learned what the book contains the impression often follows that good progress has been made in gaining knowledge of the subject which may be very far from the truth. Something like what is now called the "laboratory method" will certainly take the place of a large part of the time and effort put forth by an immature student to get the meaning of the author who has written a scholarly book which is more a manual or a ready hand-book in the science than it is a suitable text-book for a novice. The fact is apparent and it has been recently the source of much discussion in the minds of those who teach. The trend of things is towards the inductive idea, or, what is the same thing, the "laboratory method," so called. This means that students should have test exercises, in astronomy, as those in physics now do who go to the laboratory for work, there to fix their knowledge of the principles of this science which is given in the text-book or in the lecture room. It is at once seen that such a step as this will put the student to the test of independent knowledge of the things he can see, chart, or

reason out as compared with what he can learn and remember from a text-book. The difference between these two kinds of knowledge is very great.

(TO BE CONTINUED.)

LECTURE-ROOM DEMONSTRATION OF ORBIT OF BODIES UNDER THE ACTION OF A CENTRAL ATTRACTION.

R. W. WOOD.

Not remembering to have seen any attempt to show experimentally in the lecture room the motion of bodies acted on by a central attractive force varying inversely as the square of the distance in elliptic, parabolic, and hyperbolic orbits, I have made a few experiments with a view of determining how well these curves could be imitated by the motion of a small steel ball around a magnetic pole. The results were so good that I feel warranted in making them known, and believe that the experiment may be found useful in making more cheerful that portion of the course usually rather destitute of pyrotechnics.

The apparatus used was very simple, consisting of a circular glass plate about 40 cm. in diameter, with a small hole in the center through which projected the somewhat conical pole piece of a large electro-magnet (Fig. 1). The surface of the plate was smoked, and it was made level as nearly as possible, the axis of the magnet being of course vertical.

A small, highly polished ball of steel about 5 mm. in diameter (from a bicycle bearing), when projected across the plate, traced its path in the soot and left a permanent record of its motion.

Under these conditions gravity exerts no direct influence on the motion, and we have only the initial velocity and the central attractive force to deal with, together with the loss of velocity due to friction. There are several other circumstances which make the conditions unlike those existing in the case of two gravitating bodies in space, and taking everything into consideration, it is quite surprising what good results were obtained

The ball was blown out of a short piece of glass tubing held in the plane of the plate with varying initial velocities, and curved orbits obtained which were at least good imitations of the ellipse parabola and hyperbola.

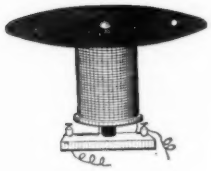


Fig. 1

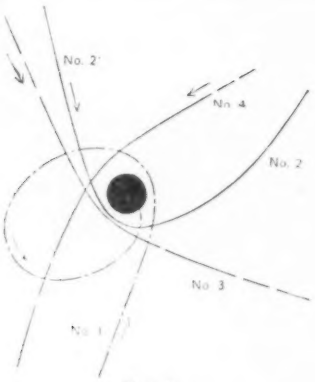


Fig. 2.

Figure 2 is a photograph* of a plate showing all three forms, the black spot in the center being the hole occupied by the magnet pole; the arrows indicate the direction of the motion.

Number 1 was produced with low initial velocity, and is a very fair representation of an ellipse, with the attractive force in one focus. The loss of velocity due to friction caused the ball to "fall into the Sun" after completing one revolution, a one year's existence of the system.

On another trial an ellipse (*spiral*, strictly speaking) was obtained that was almost re-entering, the miss being not more than a couple of millimeters, while in the one figured it was nearly a centimeter.

The right-hand branch of No. 2 resembles a parabola, and was produced by a somewhat higher initial velocity. It will be noticed that the ball moved to its perihelion position in a path rather like a hyperbola, and on rounding the pole, its velocity having been diminished somewhat, moved off in a parabola. It would be more exact probably if we called this curve an ellipse of great eccentricity, since the conditions governing the formation of a parabolic orbit would be difficult even to approximate.

Numbers 3 and 4 are hyperbolæ, produced by still higher initial velocities.

None of the orbits shown in the figure are as perfect as some that have been obtained by accident on other plates. It is quite difficult to make a plate showing all three forms with only four or five trials, as the velocity has to be nicely adjusted; conse-

* Figure 2 has been reproduced by the engraver from an untouched photograph.—Ed. *Physical Review.*

quently the curves shown in the figure must not be taken as samples of the best that can be produced by a large number of trials.

The hyperbola is of course the easiest to produce, and the parabola the most difficult. Some device for regulating the initial velocity and aim would be conducive to more uniform results.

Polarization of the steel ball is apt to give trouble, and I have obtained some repulsion orbits where the ball turns back before reaching the center, which are very pretty, but not desirable when one is trying to illustrate central attraction. Soft iron balls would be preferable to steel on this account, but they are not on the market so far as I know, and the others answer the purpose well enough.

ASTRONOMICAL PHENOMENA DURING 1900.

Eclipses.

In the year 1900 there will be three eclipses, two of the Sun and one of the Moon.

1. A Total Eclipse of the Sun, May 28, will be visible as a partial eclipse throughout North America and Europe and in the western part of Asia, the northern part of Africa and the extreme northern part of South America. This is the most important astronomical event which can be predicted for the year, and will be especially interesting to Americans, since the path of totality passes across easily accessible portions of the United States (See Popular Astronomy, No. 69, Nov. 1899, for chart of path of totality across the Southern States.)

Doubtless most of the Observatories in this country will send expeditions to observe the eclipse and to obtain all possible data concerning the wonderful corona of the Sun, which can be seen only when the Sun's disc is wholly covered by the Moon. The duration of totality is short in this eclipse; only $2^m\ 8^s$ at maximum, and that when the shadow falls upon the middle of the Atlantic Ocean. At the most favorable points in the United States totality lasts only about $1^m\ 30^s$, so that there is little time in which to make the very important and very delicate observations which are desired. Photographic and automatic processes will be employed wherever possible, thus reducing the observer's duties to a minimum and making a miscarriage of operations, due to the observer becoming confused, improbable. The great uncertainty in the case is the state of the sky. A cloud of two minutes duration over the Sun would render all preparations useless. A series of weather observations has been undertaken by the U. S. Weather Bureau, during the month from May 15 to June 15 in the last three years, at a large number of points along the path of totality, for the purpose of determining the probability of clear or cloudy weather at those localities. Professor Bigelow's discussion of these observations (Popular Astronomy, No. 69,) seems to show that chances are about three to one in favor of clear weather at stations

near the Atlantic coast and about six to one in favor of clear weather in the interior of Georgia and Alabama. We may therefore have confident expectation of some good results from all the effort and money which will be expended upon this total eclipse.

The path of totality begins in the Pacific Ocean off the coast of Mexico, crosses northern Mexico and the Gulf of Mexico, passes almost centrally over the city of New Orleans, touches Mobile, Alabama, Raleigh, North Carolina, and Norfolk, Virginia. Across the Atlantic no prominent islands lie in the track of the shadow. It touches land again on the west coast of Portugal, crosses Spain and the Mediterranean Sea, passes over Algiers and several other points on the north coast of Africa and ends near the north end of the Red Sea.

ELEMENTS OF THE ECLIPSE.

Greenwich Mean Time of conjunction in right ascension, May 28, $2^h\ 57^m\ 02^s.7$.

Sun and Moon's R. A.	4^h	19^m	$47^s.38$	Hourly motions	$10^s.16$ and		$149^s.08$	
Sun's declination	$+21°$	27′	16″.0	Hourly motion		$+0'$	24″.2	
Moon's declination	$+21$	50	17 .4	Hourly motion		$+2$	41 .0	
Sun's equa. hor. parallax			8 .7	Sun's true semidiam.		15	46 .6	
Moon's equa. hor. parallax	58	27	.4	Moon's true semidiam.		15	55 .0	

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time			Longitude from Greenwich			Latitude		
		h	m	°	′		°	′	
Eclipse begins	May 28	0	12.5	97	49.5	W.	9	59.2	N.
Central eclipse begins		1	14 5	116	38.4	W.	17	50 3	N.
Central eclipse at noon		2	57.0	45	0.4	W.	44	56.8	N.
Central eclipse ends		4	33.5	31	37.1	E.	25	20.6	N.
Eclipse ends		5	35 6	12	29.4	E.	17	32.8	N.

2. A Partial Eclipse of the Moon, June 12, will be visible generally throughout North and South America, Europe and Africa. It will, however, be of almost no importance, since the obscuration will be so very slight, only .001 of the Moon's diameter being covered by the umbra of the shadow at the middle of the eclipse.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, June 12, $15^h\ 31^m\ 30^s.0$.

Sun's right ascension	5^h	23^m	$37^s.06$	Hourly motion			$10^s.36$	
Moon's right ascension	17	23	37 .06	Hourly motion			145 .04	
Sun's declination	$+23°$	11′	16″.1	Hourly motion		$+0'$	09″.0	
Moon's declination	-22	12	57 .2	Hourly motion		$+0$	55 .3	
Sun's equa. hor. parallax			8 .7	Sun's true semidiam.		15	44 .8	
Moon's equa. hor. parallax	57	29	.7	Moon's true semidiam.		15	39 .2	

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich M. T.			Central S. T.		
		h	m	h	m	
Moon enters penumbra	June 12	13	15.0	7	15.0	P. M.
Moon enters shadow		15	24.4	9	24.4	"
Middle of eclipse		15	28.1	9	28.1	"
Moon leaves shadow		15	31.7	9	31.7	"
Moon leaves penumbra		17	41.2	11	41.2	"

Magnitude of eclipse 0.001 (Moon's diameter = 1.0).

3. An Annular Eclipse of the Sun, Nov. 21, will be visible in South Africa and Australia. This will be regarded of little importance, because the

Sun's apparent diameter will be so much greater than that of the Moon that the bright ring of sunlight at central eclipse will wholly overpower the corona.

Elements of the Eclipse.

Greenwich mean time of conjunction in right ascension, November 21, $19^h\ 22^m\ 49^s.0$.

Sun and Moon's R. A.	15^h	49^m	$26^s.34$	Hourly motions	$10^s.52$ and	$130^s.97$	
Sun's declination	$-20°$	$03'$	$59''.8$	Hourly motion	$-$	$0'$	$32''.5$
Moon's declination	-20	16	25 .8	Hourly motion	$-$	3	49 .8
Sun's equa. hor. parallax			8 .9	Sun's true semidiam.		16	11 .9
Moon's equa. hor. parallax		55	10 .1	Moon's true semidiam.		15	01 .2

Circumstances of the Eclipse.

	Greenwich M. T.			Longitude from Greenwich.			Latitude.		
		h	m	°	′		°	′	
Eclipse begins	Nov. 21	16	09.6	21	04.9	E.	1	28.2	S.
Central eclipse begins		17	26.6	2	41.1	E.	5	59.7	S.
Central eclipse at noon		19	22 8	65	49.9	E.	33	19.1	S.
Central eclipse ends		21	12.9	135	19 4	E.	18	26.8	S.
Eclipse ends		22	19.8	116	48.0	E.	13	58.8	S.

Occultations.

The *American Ephemeris* gives a list of 105 occultations of stars by the Moon, which will be visible at Washington, and therefore most of them visible throughout the United States, during the year. Among them we notice two of the planet Saturn and one of the planet Uranus which will be generally visible. They are as follows, the times being given in Washington mean time:

		Immersion.		Emersion.		Duration.	
		h	m	h	m	h	m
Saturn	March 23	13	31	14	38	1	07
Saturn	July 10	10	43	12	5	1	22
Uranus	Oct. 26	5	26	6	39	1	13

The following is the list of occultations of stars visible at Washington during January:

Date. 1900.	Star's Name.	Magnitude.	IMMERSION. Washington M. T.		Angle f'm N pt.	EMERSION. Washington M. T.		Angle f'm N pt.	Duration.	
			h	m	°	h	m	°	h	m
Jan. 8	104 Piscium	7.5	3	41	52	4	56	250	1	15
11	χ^1 Tauri	4.7	3	28	89	4	28	244	1	00
11	χ^2 Tauri	6.3	3	31	112	4	22	221	0	51
13	14 Geminorum	7.2	8	35	122	9	54	250	1	19

The Planets.

The apparent movements of the planets during the year are shown upon the charts Figs. 1, 2 and 3. If the reader will compare these charts with those published in the January numbers of Popular Astronomy for the last two years, he may be interested to note the differences as well as the general similarity in the charts. The outer planets describe exactly similar paths among the stars each year, but these paths are further toward the east each year. The inner planets describe the whole circuit of the heavens with the Sun each year, but the position and shape of the loops in their apparent paths vary from year to year.

Mercury begins the year in Sagittarius, west of the Sun, and follows a course quite similar to that of last year. Its loop in Pisces is a month earlier and is of a different shape from that described last year, the upper half of the loop being con-

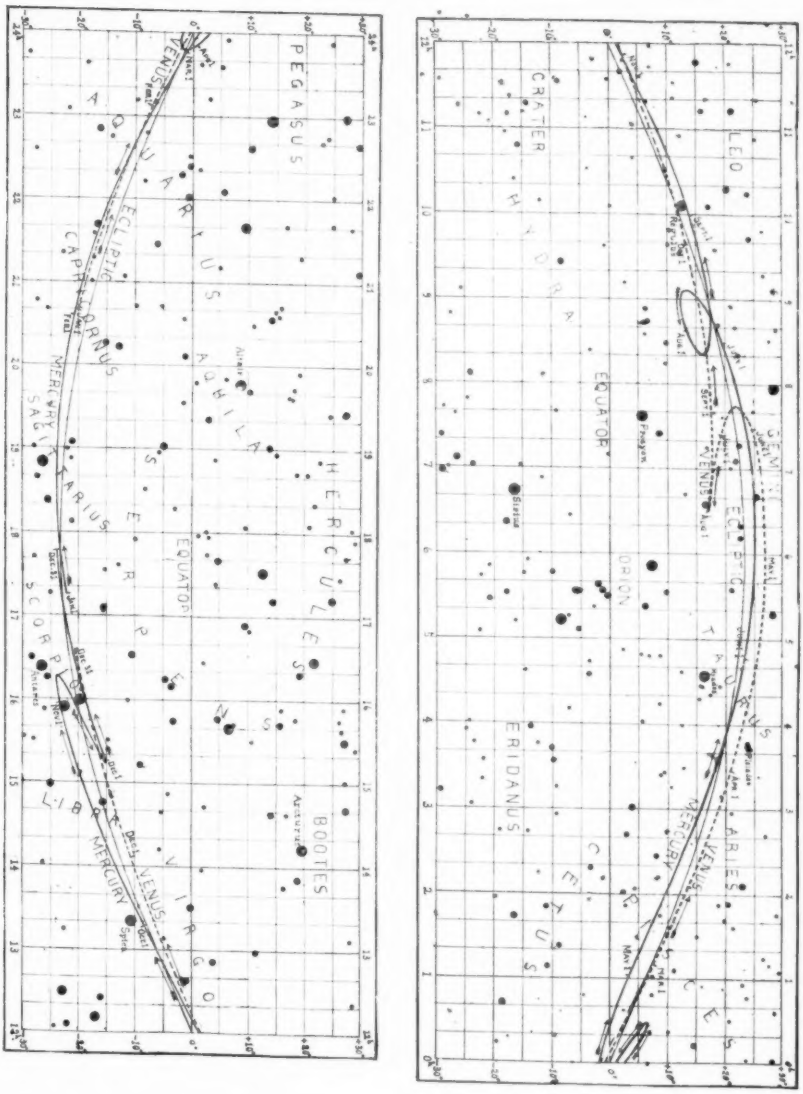


FIG. 1. CHART OF THE APPARENT PATHS OF MERCURY AND VENUS DURING 1900.

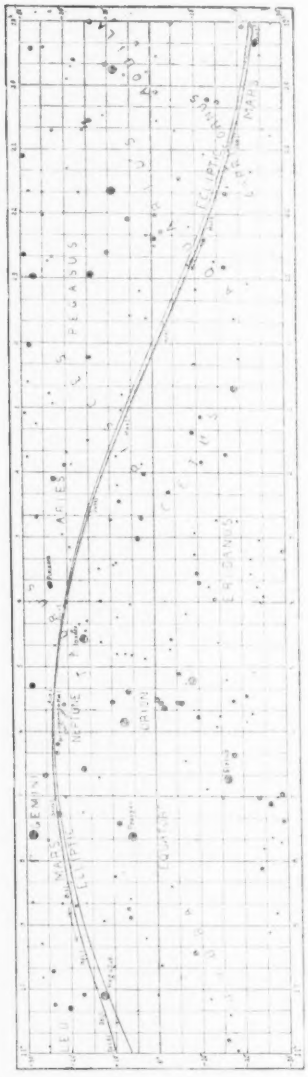


FIG. 2. CHART OF THE APPARENT PATHS OF MARS AND NEPTUNE DURING 1900.

siderably wider. The loop in Cancer made in July and August is very nearly of the same shape as last year's corresponding curve. The inverted S-shaped curve made in Scorpio in November is wider than that of last year. These different shapes are due to the differing relative positions of Mercury and Earth in their orbits. Their periods being incommensurable, the same combinations of position and motion do not repeat themselves from year to year.

The times when Mercury will be visible to the naked eye and may be therefore called "Evening Star" or "Morning Star," may be derived from the following table, remembering that the planet is visible only from one to two weeks at a time when near greatest elongation from the Sun, and that it is evening star when east of the Sun, and morning star when west of the Sun.

ASPECTS OF MERCURY.

Feb. 9.	Superior conjunction.		
Mar. 8.	Greatest elongation east	18°	16′
Mar. 24.	Inferior conjunction.		
Apr. 21.	Greatest elongation west	27	19
May 30.	Superior conjunction.		
June 4.	Greatest elongation east	26	01
Aug. 1.	Inferior conjunction		
Aug. 19	Greatest elongation west	18	32
Sept. 13.	Superior conjunction.		
Oct. 29.	Greatest elongation east	23	44
Nov. 20.	Inferior conjunction		
Dec. 7	Greatest elongation west	20	50

The path of *Venus* will be found upon the same chart with that of Mercury. It begins in Capricorn and follows approximately the course of the ecliptic until June, when for three months it describes a large loop in Gemini. For the remainder of the year the course is again eastward, near the ecliptic. Venus will be "evening star" during the first half of the year and is already very conspicuous for her brilliancy as seen toward the southwest in the early evening. She will continue to increase in brightness until June 1, a month after reaching greatest elongation, east from the Sun 45° 35′, April 28. During the spring therefore Venus will be a splendid object in the western evening sky, situated very favorably for the study of her surface markings. She will come to inferior conjunction July 8 and

a month later attain her greatest brilliancy as "morning star." Venus will be at greatest westernelongation, 46° 2′, Sept. 17 and will continue to be conspicuous in the morning during the remainder of the year.

Mars moves in a smooth curve without loops, from Sagittarius a little more than half way round the sky, to Leo, following pretty closely the line of the ecliptic. Mars will be at superior conjunction Feb. 9, and will not be in favorable position until autumn, and then only in the morning hours.

Neptune's path is shown upon the same chart with Mars, but upon so small a scale that its shape can scarcely be made out. It moves back and forth practically in a straight line, retrograding from Jan. 1 to March 5, advancing from March 5 to Oct. 1, and retrograding for the remainder of the year. The planet is visible only with telescopes of considerable power.

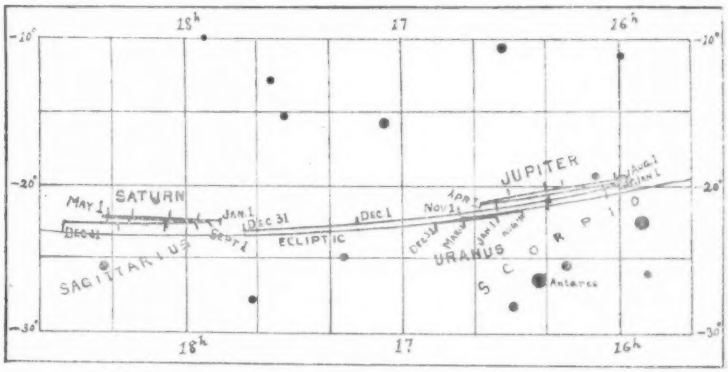


FIG 3. CHART OF THE APPARENT PATHS OF JUPITER, SATURN AND URANUS DURING 1900.

Jupiter, *Saturn* and *Uranus* are near together in Scorpio and Sagittarius. They will be in most favorable position for observation during the summer months. Their apparent paths are almost exactly alike, advancing for three months, retrograding for four months and again advancing for five months.

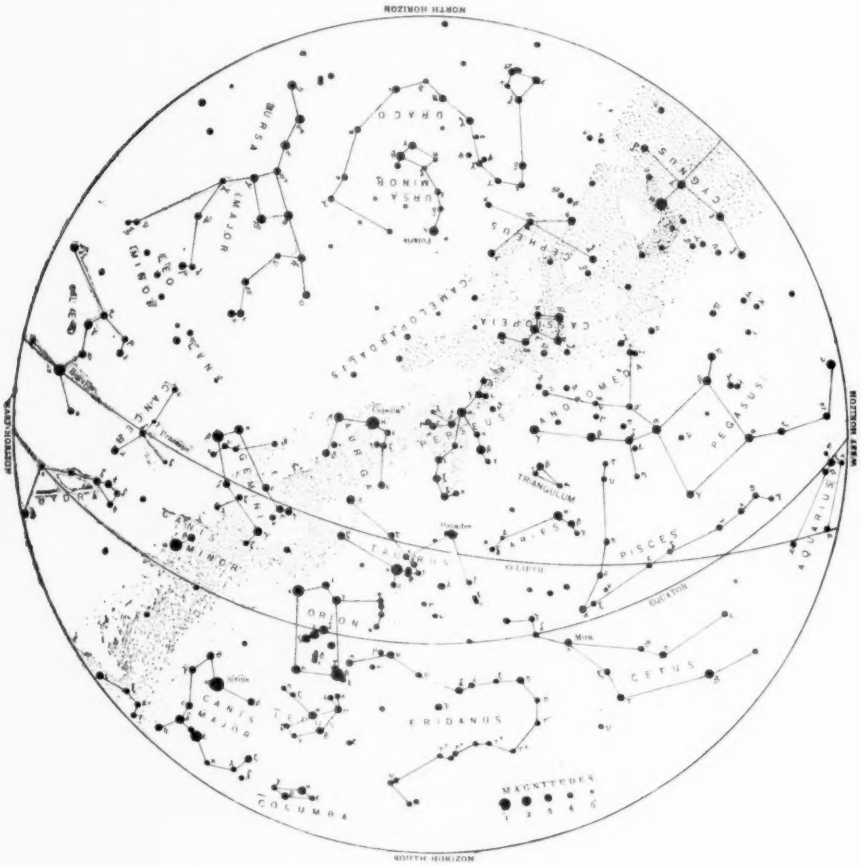
ASTEROIDS

New minor planets will doubtless continue to be discovered by the photographic method. The number now known of these little bodies is over 450, so that their discovery is of much less importance than it was fifty years ago. Most of those found now are extremely faint, but occasionally one is discovered which can be observed with a small telescope. Such an one was found by Charlois at Nice, France, on the night of Dec. 4, 1899, in right ascension $4^h\ 37^m\ 56^s$ and declination north 14° 13′. It was of the tenth magnitude and moving westward 56ˢ and northward 4′ daily.

The most notable discovery in this line during recent years was that of the asteroid Eros (433) by Witt at Heidelberg Aug. 13, 1898. This planet is extraordinary in the fact that its orbit extends within that of Mars and thus approaches nearer to the Earth than any other of the minor or major planets. An ephemeris of this planet for the months of March, April and May has been communicated to us by Professor H. A. Howe, Director of the Chamberlin Observatory of the University of Denver, Col., and is given on another page.

COMETS.

Three periodic comets are expected to return to perihelion this year. All are faint and can only be seen with a telescope.



THE CONSTELLATIONS AT 9 P. M., JANUARY 1, 1900.

Finlay's comet, discovered in 1886 seen again at its return in 1893, should be at perihelion about the end of February, but will be so unfavorably situated that its rediscovery is doubtful.

The DeVico-Swift comet, discovered in 1844 by DeVico and in 1894 by Edward Swift, son of Dr. Lewis Swift, is due at perihelion in August. It should be in quite favorable position for observation during the summer and autumn. It was however exceedingly faint in 1894, and may be found with difficulty this year.

Barnard's comet 1884 II, which has not been seen at the last two returns, if we except an uncertain observation by Swift in 1895, should be at perihelion in October. Its position will be about as favorable as in 1895, and perhaps a little better, so that there is a possibility of its being found.

No ephemeris of any of these objects is yet at hand.

Brorsen's comet, which has been lost since 1879, should be at perihelion about the close of this year and in fairly good position for observation. The fact, however, that it was not found at the equally favorable opposition of 1890, leads astronomers to think that something has happened to change the course of this comet. Dr. J. R. Hind and Dr. E. Lamp in *Astronomische Nachrichten*, Vol. 137, p. 110, point out that possibly Denning's comet 1894 I may have been a fragment of Brorsen's comet, the two objects having been in nearly the same position in space in February and March, 1881. Denning's comet is due at perihelion in June, 1901.

METEORS.

After the failure of the great Leonid shower to materialize in November last it may be rash to make any more predictions concerning it, but there are several indications that the prediction of last year was a year, possibly two years, early, and that we may look for fine showers in 1900 and 1901. The observations seem to indicate that the maximum of the shower this past year occurred on the morning of Nov. 15, instead of Nov. 16 as predicted by Messrs. Johnstone and Stoney, so that probably the maximum next November will be on the date predicted by Mr. Denning (See POPULAR ASTRONOMY No. 69, Nov. 1899, p. 479).

The Andromede or Bielid shower occurred in 1899 on the night of Nov. 24, and will probably not be noticeable in 1900.

The following table of the radiant points of the more prominent meteoric showers by Mr. W. F. Denning is abstracted from "the Companion to the Observatory" for 1900.

	Radiant.		
1900.	R. A.	Decl.	Meteors.
Jan. 2	230°	+ 53°	Swift; long paths.
Apr. 20	270	+ 33	Swift
May 6	338	− 2	Swift; streaks.
July 28	339	− 12	Slow; long
Aug. 10	45	+ 57	Swift; streaks.
Oct. 18	92	+ 15	Swift; streaks.
Nov. 14-16	150	+ 22	Swift; streaks.
Nov. 23 24	25	+ 44	Very slow; trains.
Dec 10-12	108	+ 33	Swift; short.

The Perseids, with a maximum on August 10, are visible for a considerable period and the radiant exhibits an easterly motion among the stars, changing from R. A. 20°, Decl. + 51°, July 19, to R. A. 53°, Decl + 58°, Aug. 16.

Ephemeris of Eros.—The following ephemeris of Eros has been computed with the elements given by Henry Norris Russell in *A. J.* 457.

EPHEMERIS FOR GREENWICH MIDNIGHT

Date. 1900.		α			δ			log Δ
		h	m	s	°	′		
March	1	20	51	35	− 19	1.5		0.40719
	3	20	56	9	18	37.5		0.40543
	5	21	0	39	18	13.1		0.40361
	7	21	5	9	17	48.4		0.40173
	9	21	9	37	17	23.3		0.39977
	11	21	14	3	16	57.8		0.39775

Date. 1900.	α h	m	s	δ °	′	log Δ
March 13	21	18	27	− 16	32.0	0.39566
15	21	22	49	16	5.9	0.39349
17	21	27	10	15	39.4	0.39126
19	21	31	29	15	12.0	0.38896
21	21	35	46	14	44.5	0.38659
23	21	40	2	14	18.1	0.38415
25	21	44	16	13	50.3	0.38164
27	21	48	28	13	23.3	0.37906
29	21	52	39	12	54.0	0.37640
31	21	56	48	12	25.4	0.37367
April 2	22	0	56	11	56.6	0.37086
4	22	5	2	11	27.5	0.36798
6	22	9	7	10	58.1	0.36503
8	22	13	10	10	28.5	0.36201
10	22	17	12	9	58.7	0.35891
12	22	21	12	9	28.7	0.35574
14	22	25	11	8	58.4	0.35250
16	22	29	9	8	27.8	0.34919
18	22	33	6	7	57.1	0.34580
20	22	37	1	7	26.7	0.34233
22	22	40	55	6	55.0	0.33879
24	22	44	48	6	23.6	0.33517
26	22	48	39	5	52.1	0.33147
28	22	52	30	5	20.2	0.32769
30	22	56	19	4	48.4	0.32384
May 2	23	0	8	4	16.3	0.31990
4	23	3	55	3	44.0	0.31589
6	23	7	41	3	11.5	0.31179
8	23	11	26	2	38.8	0.30762
10	23	15	10	2	6.0	0.30337
12	23	18	53	1	33.0	0.29904
14	23	22	35	0	59.9	0.29463
16	23	26	16	− 0	26.6	0.29014
18	23	29	50	+ 0	6.8	0.28557
20	23	33	36	0	40.4	0.28091
22	23	37	15	1	14.2	0.27617
24	23	40	53	1	48.1	0.27134
26	23	44	30	2	22.3	0.26643
28	23	48	1	+ 2	56.4	0.26143

DANIEL N. JONES, JR.

SPECTROSCOPIC NOTES.

In *Science* of Dec. 1 and Dec. 8 abstracts are published of the papers, about a third of them spectroscopic, presented last summer at the first meeting of the Astronomical and Astrophysical Society of America.

The relative photographic brightness of Mars and Jupiter has been measured by Dr. J. Hartmann at Potsdam (*Berlin Sitzungsberichte*, July 20, 1899; *Astrophysical Journal*, Nov.) Using a new type of photometer he finds that for the light of greatest photographic activity (λ 4760 to λ 4110) the surface brightness of Jupiter is almost exactly identical with the surface brightness of Mars, while the surface brightness of the brightest—southwest—portion of the Moon is about one fourth that of either planet. The distance of Jupiter from the Sun was a little less than 3.5 that of Mars; the intensity of illumination,

varying as the square of the distance inversely, was consequently for Mars 11.9 that for Jupiter. In order that the surface brightness should be the same for the two planets the reflecting power, or albedo, of Jupiter must for the part of the spectrum under consideration be 11.9 that of Mars. The visual albedo of Jupiter Professor Müller has found to be 2.8 that of Mars, as against Dr. Hartmann's ratio of 11.9 for the violet albedo, while Professor Lohse has found Jupiter's photographic albedo, where the ultra-violet is effective in addition to the violet, to be 18 8 that of Mars. Evidently the violet of Mars is relatively weak, and the ultra-violet very weak; as might be expected from the planet's pronounced reddish color.

In the *Astrophysical Journal* for November Mr. Harrer of the Allegheny Observatory gives the results of his examination of the spectrum of α Orionis during the star's irregular minimum at the past opposition. Comparing his spectrograms of this period with Professor Keeler's spectrograms of 1894 he has detected no change in the number or relative intensities of the lines in the green and yellow of the spectrum.

The American Academy of Arts and Sciences have appropriated the sum of $500 to assist in the construction of a large spectroscope to be used at the Yerkes Observatory by Professor Frost for the determination of motion of stars in the line of sight.

In the choice of officers of the British Astronomical Association Mr. J. Evershed was reëlected for the current year director of the section of spectroscopy.

A summary is given in *Science* of Dec. 8 of the results of Dr. Chase's careful investigation of the refraction of red stars. While the excess of red light in these stars might be expected by its smaller retrangibility to diminish the amount of their general refraction, Dr. Chase agrees with previous observers in finding that the refraction for the red stars is the same as for the other stars.

In the *Astrophysical Journal* for November Professor Campbell reports that he finds variable motion in the line of sight for β Capricorni and υ Sagittarii.

In the forthcoming 'Revised Harvard Photometry' a column is promised giving, for each star whose magnitude has been determined, the character of its spectrum; and also, where possible, the photographic magnitude will be given, by comparing which with the visual magnitude the star's color may be determined.

Dr. Wilsing, continuing his investigation of the effect of pressure on spectra, has obtained (*Astrophysical Journal*, November,) by moistening carbon electrodes with water, results for hydrogen analogous to his previous results for other elements.

Professor Hale has recently confirmed and extended his observations of carbon in the Sun's chromosphere (Yerkes Observatory Bulletin No. 12; *Astrophysical Journal*, November,). The green fluting of carbon, terminating at λ 5165 was found in the chromosphere as long ago as September, 1897, the identification of the feeble bright lines of the fluting in the chromosphere being accomplished by

first putting the slit of the spectroscope on the Sun's disc and then moving quickly to the Sun's edge, when the dark carbon lines were replaced by bright lines. In Aug. 1899 with the reconstructed spectroscope this green fluting was observed better than before, a large number of bright lines being visible. With perfect conditions and adjustments the yellow fluting, terminating at λ 5635, was seen. The blue fluting, which terminates at λ 4737, could not be seen.

VARIABLE STARS.

J. A. PARKHURST.

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time.)

1900.

ALGOL.

	d	h
Feb.	7	17
	10	14
	13	11
	16	8

U CEPHEI.

	d	h
Feb.	1	7
	3	19
	6	7
	8	19
	11	6
	13	18
	16	6
	18	18
	21	6
	23	18
	26	5
	28	17

S VELORUM.

	d	h
Feb.	5	18
	11	17
	17	15
	23	14

λ TAURI.

	d	h
Feb.	8	13
	12	12
	16	10
	20	9
	24	8
	28	7

R CANIS MAJ.

Every 8th min.
P = $1^d\ 3^h.3$

	d	h
Feb.	6	1
	15	4
	24	6

δ LIBRAE.

	d	h
Feb.	4	17
	11	17
	18	17
	25	16
	28	0

U CORONAE.

	d	h
Feb.	1	19
	8	17
	15	15
	22	13
	26	0

RS SAGITTARII.

	d	h
Feb.	0	16
	5	12
	7	22
	12	18
	17	14
	24	20

DM + 45°3062.

	d	h
Feb.	1	6
	5	20
	10	10
	14	23
	19	13
	24	3
	28	17

U OPHIUCHI.

Every 10th min.
P = 20.1^h

	d	h
Feb.	5	4
	13	13
	21	23

DM + 12°3557

	d	h
Feb.	2	0
	2	21
	3	18
	4	16
	10	0
	10	21
	11	18
	12	16
	18	0
	18	21
	19	19
	20	16
	26	0
	26	21
	27	19
	28	16

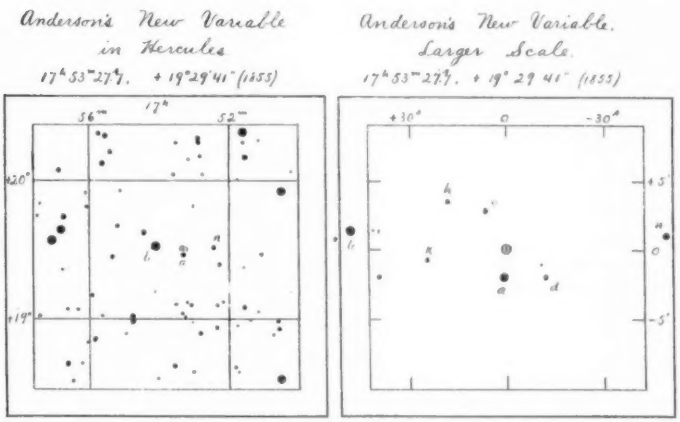
The above ephemeris was computed from the elements given in Chandler's Third Catalogue with three exceptions. For U Cephei, Chandler's revised elements given in No. 396 of the *Astronomical Journal*; for DM. + 12°3557, Luizet's elements given in No. 3596 of the *Astronomische Nachrichten*; for DM. + 45°3062, Pickering's elements given in Harvard College Observatory Circular, No. 44. The long period variables must still await the appearance of an ephemeris in the *Vierteljahrsschrift* or the *Companion to the Observatory*.

ANDERSON'S NEW VARIABLE IN HERCULES.—This is the first of the new variables noted on page 537 of the December number. The place there given is—

R. A. $17^h\ 53^m\ 27.7^s$ Decl. $+19°\ 29'\ 41''$, (1855)
$55\ \ 24.7$ $29\ \ 20$ (1900)

The place was also measured by Dr. Hartwig with the 7-inch heliometer of the Remies Observatory in Bamberg, Germany. He gives as his results in No. 3603 of the *Nachrichten*—

R. A. $17^h\ 53^m\ 27.60^s$ Decl. $+19°\ 29'\ 40.1''$, (1855)



The accompanying charts will aid in finding the field, which is 1° south of the 4.5 magnitude star *95 Herculis*. The first chart, on the scale of the DM, gives the stars from the 6th to the 9.5 magnitude within a degree of the variable. The star *a* is DM. + 19°3439, *b* is 19°3494, and *n* is 19°3484. The larger scale chart gives enough of the stars from the 6th to the 12th magnitude within 10′ of the variable to identify it in its fainter stages.

COMPARISON STARS FOR ANDERSON'S NEW VARIABLE IN HERCULES.

	Co-or. from V. R. A.	Decl.	Mag.		Co-or. from V. R. A.	Decl.	Mag.
	s	′			s	′	
n	−11.3	−48.3	+0.5	*k*	+ 5.7	+24.2	−0.7 11.1
d	− 2.9	−12.1	−2.0 11.2	*f*	+ 8.1	+34.3	−2.0 10.2
m	− 2.5	−10.8	−1.0 12.2	*l*	+ 8.1	+34.4	+1.4 11.0
a	+ 0.2	+ 0.9	−2.0 9.5	*b*	+10.1	+43.0	+1.3 6.5
c	+ 1.6	+ 6.8	+2.9 10.9	*g*	+11.3	+47.9	+0.8 10.9
h	+ 4.2	+18.0	+3.3 11.1				

The magnitudes of the comparison stars are merely approximate, for the purpose of identification.

The variation of this star has been somewhat rapid, as the following list of observed magnitudes will show,

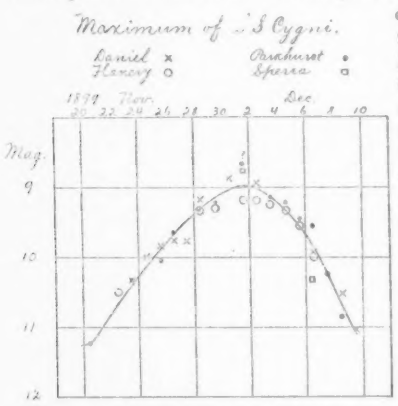
		Mag.				Mag.	
1899	Aug. 22,	9.0	Anderson,		23,	11.9	J. A. Parkhurst.
	24,	9.0	"		28,	12.4	"
	Sept. 17,	9.9	"	Nov.	4,	12.4	"
	Oct. 12,	11.2	J. A. Parkhurst,		8,		"
	17,	11.4	"		to		"
	20,	11.8	"	Dec.	5,	<12	not seen, 5 obs.
	21,	11.9	"				

Dr. Hartwig, in the place above cited, reports a decline of 0.25 magnitude between Oct. 3 and 14.

When these observations are platted it will be seen that there is no check in the rapidity of the decline, and therefore no signs of an approaching minimum. The curve resembles that of Anderson's former discovery in this constellation, 6100 RV Herculis (See POPULAR ASTRONOMY, V, 326), which was followed below the 15th magnitude with the 40-inch Yerkes telescope. (*Astronomical Journal*, No. 456). If this resemblance is confirmed the star may reappear after minimum in the spring of 1900, in position for morning observation.

THE SPECTRUM OF α ORIONIS DURING THE RECENT MINIMUM.—Mr. Henry Harrer, of the Allegheny Observatory, took six spectrograms of α Orionis during the interval 1898 December 24 and 1899 April 5, to seek for any spectral changes which might accompany the recent minimum. These plates were compared with three taken by Professor Keeler with the same instrument and the same adjustment in October and December 1894. The results of this comparison are thus stated by Mr. Harrer in a note in the *Astrophysical Journal* for November 1899. "The comparisons revealed no changes either in the number or relative intensities of the lines. The above six photographs therefore revealed no change in the spectrum of α Orionis within the limits which have been stated." About 130 lines were compared, between λ 5130 and 5655.

ANOMALOUS MAXIMUM OF SS CYGNI.—If any apology were needed for the frequent reference to this variable, it would be furnished by Professor Bailey's discovery of so many examples of this type of variation in the cluster Messier 5, already noted in these columns. But these cluster variables are beyond the reach of an ordinary telescope, while all the changes of SS Cygni can be followed with a moderate aperture, so we must look to this star for most of our knowledge of this type of variation.



The maximum just passed was unique in character. Nothing like it has been seen before, or at least been published, in the light changes of this star. If the form of curve for this maximum depended on the comparisons of a single observer, the report would perhaps be doubted, but the observations of the four are in so satisfactory agreement that the anomalous form of the curve seems well established. The accompanying graphic representation will show at once the form of the curve and the agreement of the observations (Compare curves in V, 271 and 387, VI, 159 and VII, 145). The star had reached normal light after the October maximum on Nov. 6, so that the period of quiescence was only 14 days, the shortest on record. The curve shows a maximum Dec. 1.7, the time of passing 9.35 magnitude during the rise being Nov. 28.1.

The number of observations reported is—

Zaccheus Daniel,	11
David Flanery,	9
J. A. Parkhurst,	41
Wm. E. Sperra,	2
Total,	36

COMET NOTES.

Definite Orbit of Comet 1894 IV, (E. Swift).—In *Astronomische Nachrichten* No. 3606-7 Mr. F. H. Seares gives detailed results of a definitive calculation of the orbit of E. Swift's comet, from all of the published observations. It will be remembered that a similarity was noted, soon after its discovery, between the elements of the orbit of this comet and those of the long lost De Vico comet 1844 I. The previous calculations, although pointing strongly to the identity of the two comets, yet left much uncertainty as to the conclusion to be derived from them. To clear up this uncertainty as much as possible has been the object of Mr. Seares' investigation, and the new determination of the elements of the comet 1894 IV has been a first step in the investigation.

The comet was so faint and the weather so bad that the total number of observations of the comet was only 64 for right ascension and 63 for declination. By comparing these observations with an ephemeris from Mr. Chandler's elements in *Astronomical Journal* No. 338 Mr. Seares formed seven normal places, and after correcting these for perturbations by Jupiter, Saturn, Mars, and Earth, calculated corrections to the elements by a least square solution of differential formulæ.

The definitive elements thus obtained are as follows:

Epoch 1594, Dec. 1.0. Osculation 1894, Dec. 10.0.

$M_0 = 8^\circ\ 22'\ 58''.2 \pm 4''.2$

$\pi = 345\ 23\ 11.1 \pm 4.4$ } 1900.0

$\Omega = 48\ 48\ 23.4 \pm 27.7$ } 1900.0

$i = 2\ 57\ 55.8 \pm 1.4$ } 1900.0

$\varphi = 34\ 51\ 37.3 \pm 7.1$

$\mu = 605''.9999 \pm 0''.0665.$

These elements place the perihelion passage on Oct. 12, 1894, and make the period 5.855 years. The next perihelion, neglecting perturbations, would be Aug. 20, 1900.

GENERAL NOTES.

It is scarcely necessary to say that the Leonids, though comparatively few in November anywhere, make something of a display in January from the pages of this magazine. Some of the charts present only a few true Leonids, and none a great many in view of what was expected, yet it has seemed best to give many reports from widely different localities in the hope that some useful data may be gained to help in solving some troublesome questions about the real location, dimensions and characteristics of the orbit of the Leonid stream of meteors.

Reports from Leonid Observers.—We have some more reports of Leonids observed in other localities not yet published. We have set aside other matter this month, and given large space to this, for reasons already given above. In presenting other reports later, we have still the same object in view, *viz.*: that of making as full a survey of the observational side as is possible under the circumstances.

The New Photographic Telescope of the Potsdam Astrophysical Observatory.—We have just received a beautiful photograph of the great telescope recently completed for the Astrophysical Observatory at Potsdam, Germany. No description accompanies the photograph and we have seen no reference to the telescope in recent publications except the barest mention that it was in the process of construction and that it was to be a photographic refractor consisting of two telescopes, the photographic objective having an aperture of 80*cm* (= 31.5 inches) and the visual objective having an aperture of 50*cm* (= 19.7 inches). The photograph (Plate I) shows the telescopes to be in position in the dome and that they have approximately the same focal length. The instrument will be of great value for photographing faint objects, like the smaller nebulae and star clusters, on a scale large enough to show their details of structure plainly. We presume also that a large part of its work will be in connection with the spectroscopic study of the fainter stars.

Orbit of the Fifth Satellite of Jupiter.—The careful and thorough work done in 1898 and 1899 in observing the fifth satellite of Jupiter by Professor E E. Barnard, with the 40 inch equatorial of Yerkes Observatory, has already received full notice at home and abroad in various scientific publications. His micrometrical observations have made it possible for the mathematical astronomers to study the orbit of this new satellite with confidence that some uncertainties about it will be removed. Years ago, Tisserand called attention to the fact that early observations showed that the orbit of the satellite had eccentricity. This led Professor Barnard to plan a series of observations of the positions of the satellite that should be as nearly continuous as possible in order to settle this question. One result which he obtains from the work of the last two years is a period of revolution for the satellite which he regards as correct to one one-hundredth of a second of time. The period given in his recent paper on this subject is

$$11^h\ 57^m\ 22^s.647.$$

Tisserand's results from early observations gave a daily motion to the apse line of $+\ 2°.42$, and an eccentricity of orbit equal to 0.0073. By Professor Barnard's later observations, it appears that Tisserand's daily motion of the apse line is too small, its true value being more nearly $+\ 2°.465$, making a complete revolution of the orbit in 4.9 months.

It is suggested by a writer in a late number of *Nature* that "an interesting question may also be settled, by continued observation of this satellite: that is, the distribution of matter at the equator of Jupiter itself, as the motion of the perijove of the satellite does not agree with that deduced from the actual polar compression of the planet." This gives opportunity for more fine micrometrical work by the aid of a large telescope.

The Astronomical Director of the United States Naval Observatory.—The expiration of the time limit for the office of Astronomical Director for Professor William Harkness at the United States Naval Observatory, Washington, D. C., occurred Dec. 17, 1899. His retirement completes the list of those men who have been long in service together in the professorships of mathematics at the Observatory, *viz*: Professors Hall, Frisby, Eastman and Harkness. The time of service of these eminent men at the Observatory has been during a transition period of the character and history of our national astronomical Observatory. When these men came it was little more than a depôt of charts with some astronomical instruments needed for the rating of chronometers and the observations for the Nautical Almanac and the American Ephemeris. The ability of these men in their chosen profession, and in a long and skillful service, faithfully rendered at their respective posts, has, more than anything else, brought the Naval Observatory to a rank worthy of a national name which it noes not yet bear. This transition period has been one of conflict, trouble, jealousy and ill-managment that have defeated much of the best work that might have added largely to the usefulness of the Observatory to astronomy and the country at large. Notwithstanding this these men have lived through it it all, and each and all of them have come to honorable retirement when they were at their best in scientific ability and experience for the performance of professional work to which they have ambitiously devoted their whole lives.

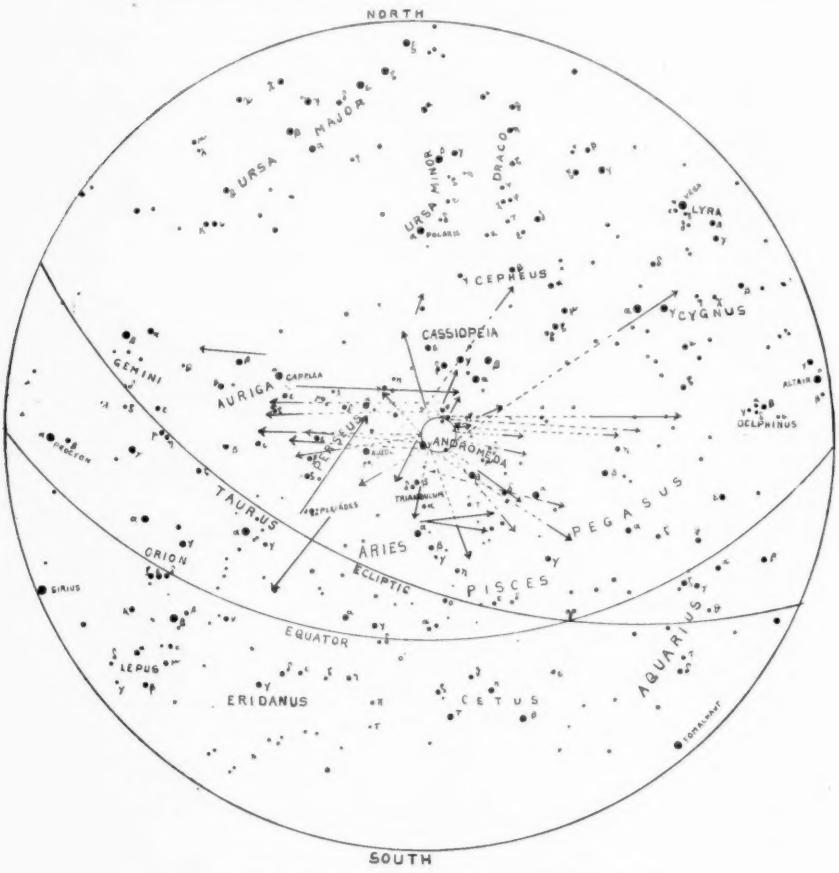
From a recent number of the Washington *Star*, we copy the following statement about Professor William Harkness, who is the last in retirement of the four persons referred to:

"Professor Harkness was born in Scotland, Dec. 17, 1837, and came with his father, who was a Presbyterian minister, to the United States when a mere child. He entered the University at Rochester, N. Y., and graduated in 1858. He studied medicine in New York, became an M. D. in 1862, and enlisted as a surgeon in the Federal army. He resigned that position, was appointed an aid in the United States Naval Observatory in 1863, and became a professor of mathematics the same year.

"His first scientific work was with the the United States monitor Monadnock, in 1864-5 in investigating compasses and iron-clad vessels. On his return he was attached to the Hydrographic Office. While observing a total eclipse of the Sun at Des Moines, Iowa, in 1869, he discovered the 1874 line of the Solar-Corona. In 1871 Professor Harkness was attached to the 'Transit of Venus Commission,' and designed the instruments of the expedition. In 1878 he was placed in charge of the government party which observed the total eclipse of that year at Creston, Wyo. In 1882 he was made executive officer of the 'Transit of Venus Commission,' and reduced the photographic work of the numerous observations taken.

"Among his inventions are the sphereometer caliper, for measuring inequalities of the pivots of astronomical instruments. In 1890 Professor Harkness was made astronomical director of the United States Naval Observatory. In 1897, on the retirement of Professor Newcomb, he was made head of the Nautical Almanac. As a member of various scientific societies, he has contributed numerous reports on mathematical astronomy and the application of mechanics to astronomy. His 'Solar Parallax and its Related Constants" is one of the most important. Professor Harkness has been honored with the degree of A. M., Lafayette College, and with the degree of LL. D. from Rochester University. He will continue his scientific work in Washington in his retirement.

The Andromede Meteors.—The nights of Nov. 22 and 23 were cloudy at Northfield. The 24th was perfectly clear up to 10^h P. M. and a considerable number of meteors were seen by several persons. On account of another engagement systematic watch was not kept until after 10^h.



METEORS CHARTED DURING THE ANDROMEDE SHOWER,

Nov. 24, 1899, by H. C. Wilson and students at Goodsell Observatory.

In the first five minutes, one observer counted 10 meteors, all from Andromeda, while the others were getting the apparatus for charting into position. After this the meteors came more slowly and soon clouds covered the sky, lasting until about 11^h, when the sky cleared again and remained clear until the Moon rose. The shower was evidently nearly over at 11 o'clock, for after that, though the sky was perfectly clear, the meteors were very few. The few that were

charted between 10 P. M. and 1 A. M. place the radiant about one-third of the way on a line from γ to φ Andromedæ.

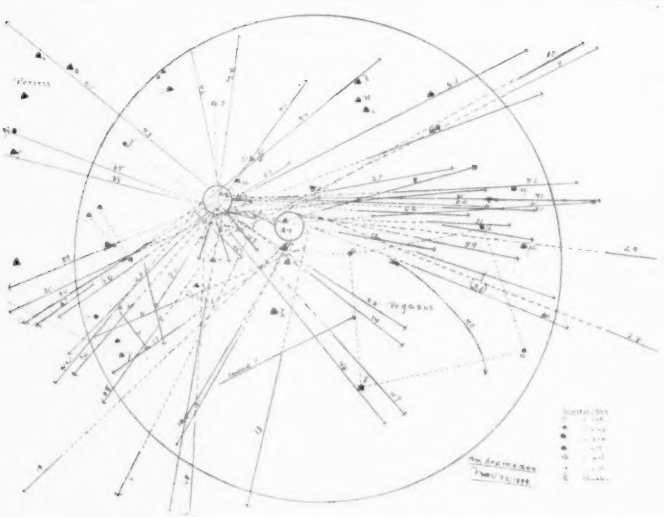
On the evening of the 25th watch was kept occasionally but no Andromedes were seen.

The Andromedes.—The Andromedes shower was a fine one for one night. On November 20, 1899 I watched for forerunners. The sky was half overcast. But in spite of that I saw one of the third magnitude at 7.10 of a white color. The 21st, 22d and 23d were cloudy. But on the 24th the sky was excellent. A cloudless and moonless sky. I began observations at 7:00 sharp. I had a table, chair, clock and maps and instruments. I noticed all through the night that the Taurids were also at their best, and I saw eleven in all, while fixing my attention on the constellation Andromeda. They were all bright and four very bright ones. I saw at one time three in one minute all of 0 magnitude. Saw in all sixty-four Bielids during the time between 7:00 and 10:02. Two on different nights. One on the 20th and one on the 25th the only one I saw between 7:00 and 8:30. Most of them were fairly bright: I saw two of 0 magnitude; one in the north-west and another that went through Pegasus and left a two-portioned trail of a green to blue color. This trail lasted two seconds. I had a camera ready, but did not set it because I thought the shower would be better the next night.

To sum up my observations:—

Time.	Mag.	Class	Color	No.	Remarks.
h m					
7 0	4	A	W	1	
7 3		A(M)	W	2	
7 6		(A)M	W	3	
7 7		A	W	4	
7 10	0	A	G	5	Very brilliant two portioned
7 14	1	T	W	6	trail 1 mag. G.
7 15		A	W	7	
7 17		T	W	8	
7 21	3	A	G	9	
7 22	5	T	W	10	
7 24		A	W	11	
7 28		A	W	12	
7 31	3	A	W	13	
7 31	2	A	W	14	
7 34	3	A	W	15	
7 35	2	T	W	16	Fine trail.
7 36	1	A	R	17	Very swift.
7 36	3	A	W	18	
7 40	4	A	W	19	
7 41	1.5	A	W	20	Trail 2 seconds green.
7 48	3	A	W	21	Very slow.
7 51	4	A	W	22	
7 55	4	A	R	23	
7 57	1	A	G	24	Trail. Whizzing noise.
7 58	2	A	W	25	Very lengthy.
8 1	4	A	R	26	Near radiant.
8 4	4	A		27	
8 12	2-3	A	W	28	
8 12	1	M	G	29	Swift green meteor.
8 17	3	A	G(R)	30	Was two colors.
8 19	3	A	G	31	
8 23	1	A	W	32	Trail 1 second.
8 33	2	A	W	33	Trail 2 seconds
8 35	2	A	W	34	
8 37	2	A	W	35	
8 39	2	A	W	36	
8 40	2	A	W	37	Very faint trail.
8 42	3	A	W	38	
8 42	2.5	A	W		
8 43	4.1	A	W	39	

Time.	Mag.	Class	Color	No.	Remarks.
h m					
8 45	3.5	A	W	40	
8 46	3.5	A	W	42	
8 47	4	A	W	43	
8 48	2	A	W	44	Trail 2 seconds.
8 49	3	A	G	45	
8 53	4	A	W	46	
8 54	4	A	W	47	
9 1	3	A	R	48	
9 1	2	A	R	49	
9 4	1	A	R(W)	50	Trail 2 seconds.
9 5	3	A	R	51	
9 7	3	A	R	52	Off map in west.
9 9		A	W	53	
9 11	3	A	R	54	
9 12	1	A	W	55	
9 14	2	A	W	56	
9 19	3	A	W	57	
9 23	1	T	W	58	
9 24	1	A	W	59	Trail 2 seconds.
9 30	1	A	W	60	
9 32	1	A	G	61	
9 33	1	A	Y(R)	62	Faint green trail.
9 34	1	A	G	63	Trail 1-5 second.
9 36	0	A	W	64	Very bright off map.
9 38	3	A	R	65	Went clear across heavens.
9 40	6	A	W	66	
9 41	1	A	W	67	
9 47	3	A	W	68	
9 48	2	A	R	69	
9 51	3	A	W	70	
9 53	5	A	R	71	
10 1	1	A	W	72	Left a two part trail 1 mag.
10 2	3	A	W	73	
10 5	4	A	W	74	
10 6	1	A	W	75	
10 15	0	A	W	76	Green trail.
9 55	1	1	R	77	Went clear across the sky.
9 55	0	T	W	78	
9 55	0	T	W	79	
				80	



The whole number of meteors was 80, consisting of Taurids, Bielids or Andromedes and two shooting stars. I did not, by good luck, sit up until 11:00 or probably the number of meteors would have been perhaps over a hundred. There were two radiants on the map (A–1) and (A–2). The meteors started at first near the star δ and then gradually moved to β Andromedae.

ROBERT M. DOLE.

GLEN ROAD, Jamaica Plain, Boston, Mass.

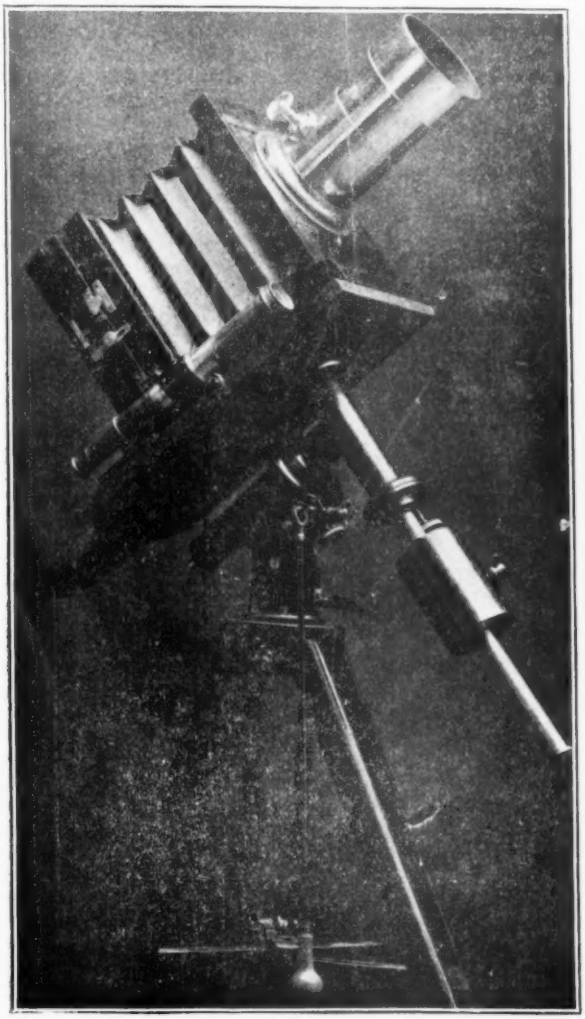
An Interesting Object.—Near 5:30 P. M. on Thursday, Nov. 2, 1899, a hazy light spot, something like a fiery mist, large enough to easily attract attention, made its appearance near the horizon, north of east. This spot became rapidly distinct as it approached, changing from a hazy mist into a redder ball, which changed into a peculiarly beautiful white light, becoming more defined and with a luminous train growing larger and brighter and more beautiful as it slowly glided westward. Its course from the point where it appeared was due west and moving in a straight line almost parallel to the horizon lasted fully one minute. When at about two-thirds of its flight across the sky the ball of light seemed not to explode but rather part into three distinct bodies which moved on in the same path. Gradually the two bodies following separated from the head until at a certain distance which was kept the remainder of their flight. The second ball, smaller than the other two, keeping midway between.

Presently the face of the head light began to dissolve into fiery red flakes that were soon flying about the two bodies following which were almost lost to view but could be distinguished by their whiter appearance. At a point almost due north the lights, while making a short turn from their unvaried straight course, disappeared leaving a very dark curl of smoke. FRED HATCH.

BALDWIN, Kansas.

Leonids at New York City.—It may interest you to hear from your asteern observers of the Leonid meteors, our Mr. Chas. Lembke, Mr. Otis

Wattles and Mr. Holtz of the Goerz Lens Co., Berlin. We stationed ourselves at the Brooklyn Museum of Arts and Sciences, provided with cameras equatorially mounted provided with finder and slow motion in right ascension. The lenses used were 4-4 portrait tube and lenses ground by Chas. Lembke, Jr. The other camera was supplied with a Goerz astigmat wide angle lens.



PHOTOGRAPHIC CAMERA BY GALL & LEMBKE.

Our disappointment was very great, as our station, free from houses or any interference except the brilliancy of moonshine. We have not seen a single meteor neither on Thursday 1 A. M. to 4 A. M., nor the following morning.

GALL & LEMBKE.

The Foucault Pendulum Experiment.—A brief article appears in No. 9 of the Journal of the British Astronomical Association concerning the Foucault Pendulum experiment to show the rotation of the Earth on its axis. This experiment was first performed by Foucault at the Panthéon, in Paris in 1851. From the article, above referred to, it is learned that nearly two centuries before this date, those who were experimenting with the pendulum at Florence had observed the rotation of the plane of oscillation, and that Vincenzo Viviani, the pupil of Galileo, had recorded the observation "in a note which was found amongst his writings relating to the motion of the pendulum but which remained unpublished." The members of the Florence Academy understood this fact thoroughly, but they could not give the reasons for it. The demonstration as we now know was first given by Foucault about two centuries later.

It is easy to perform the experiment in a rough way, now, and it is doubtless done in most colleges of this country which use the laboratory methods in teaching astronomy to any considerable extent. We have at Carleton College shown the rotation of the plane of oscillation with a pendulum only 12 feet long in less than one half hour. We have used a smooth sphere of iron 8 inches in diameter weighing 100 pounds and suspended it with steel wire so as to give a length of about 24 feet. If carefully suspended such a pendulum will swing for two or three hours, and show a deviation of plane of vibration at the rate of 10 degrees per hour, roughly, in latitude 45°, and *always* in the right direction to show rotation of the Earth to eastward. When we could get a chance to swing the pendulum with a length of 100 feet, as has been true in one instance, in the use of the steeple of a large church, the results came out beautifully and with greater accuracy in swings of about one hour periods. To gain accurate results by such an experiment the mounting of the pendulum must be done with very great care.

Lowe Observatory, Echo Mountain, Dec. 9, 1899.—I have read in the November number of POPULAR ASTRONOMY Mr. Herman Davis' description of a lunar rainbow as seen by him. I subscribe to his assertion that they are somewhat rare from my own experience, having during the past 60 years seen but few. This calls to mind a desire I long have felt to learn if many of the readers of your Popular Astronomical Journal ever saw a solar rainbow in the north? I have seen but two, and therefore conclude that the phenomenon is of rare occurrence, in fact, reason teaches that it *must* be rare, for it depends on the simultaneous occurrence of four distinct events: 1st, it must (say in the middle states) occur during the three winter months; 2d, it must take place at noon; 3d, it must be raining in the north; and 4th, the Sun must be shining in the south. As the apex of the bow is low, it also requires to see it an unobstructed northern horizon.

My last and the most conspicuous of the two was seen from the elevated tower of the Warner Observatory in Rochester, N. Y., some eight years ago. In Southern California it so seldom rains a rainbow in any direction is rarely seen. I have seen on a few occasions detached pieces of one, but seldom is one seen entire from horizon to horizon.

LEWIS SWIFT.

Eclipse of the Moon at Des Moines, Ia.—The eclipse of the Moon, Dec. 16, 1899, was observed and enjoyed by a large number of the citizens of Des Moines.

The disappointment in not seeing the expected Leonids, Nov. 12-16, led to skepticism, on the part of some people, as to the calculations and predictions of astronomers, and confidence was in a measure restored by seeing the eclipse occur at the hour predicted.

The first contact was not generally well seen because of clouds near the horizon, but within a very few minutes the arc of the segment of the shadow was plainly visible on the Moon.

While the sky was slightly hazy the entire evening, yet it was sufficiently clear to make the eclipsed Moon a beautiful naked-eye object from 6 to 9 P. M.

At the middle of the eclipse the center of the Moon was quite dark, but the "seas" showed up finely in the finder of the telescope, and Tycho was quite easily seen. The very slightly protruding rough edge of the bright limb was interesting.

The copper hue before, at, and after, the middle of the eclipse was readily noticeable. W. A. CRUSINBERRY.

Leonids at Cleveland, Ohio.—With ten assistants from my astronomy class I watched for meteors from Monday to Friday night inclusive, November 13th to 18th. During this time we had one hour of clear sky on Friday morning. We counted five meteors and photographed three 8 x 10 plates. The weather was most unfortunate and the results obtained here are of no value whatever. I write you personally, not for publication, to let you know that we tried to do our part in watching this shower. CHAS. S. HOWE,

Professor of Astronomy.

CASE OBSERVATORY, Case School of Applied Science, Cleveland, Ohio.

Leonids and Andromedes at Carlisle, Pa.—I beg to make a brief report of recent meteoric observations in this vicinity. Cloudy weather interfered very disappointingly on Nov. 13, 14, 15 and 16th and our party saw but one Leonid, although we kept up our constant watch for hours each night. We were well situated on an elevation away from the glare of the electric lights of town and had charts, etc., ready, but the clouds persisted in intervening.

However, the observations from Andromeda were more encouraging. The number seen on the night of Nov. 22-23 was 89, including one of wonderful brightness going toward and nearly to St. Cygnus. Others were faint by comparison as this big one cast a distinct shadow. The course was straight and the trail was visible for some seconds afterwards.

A party of five of us saw 161 meteors on the following night. These were all from Andromeda, with the exceptions of several Cassiopeids and a very pretty Leonid, the latter going as far west as Polaris at 12.30 A. M. on Nov. 24th. A number of the Andromedes were particularly brilliant and created much enthusiasm. The average was about one per minute. At intervals there would be three or four in rapid succession and in two instances there were two going in the same direction at the same time. The sky was cloudless and all of the constellations were exceedingly clear and distinct. E. N. FOUGHT.

CARLISLE, Pa., Nov. 30, 1899.

The Central Star in the Ring Nebula.—In *Astron. Nachr.*, No. 3607, Mr. W. Stratanoff, of the Tachkent Observatory, Russia, gives the results of a

study of some 70 photographs of the Ring Nebula in Lyra, with reference to a variation in the brightness of the central star, which is shown in all photographs, but which is visible to the eye only with the aid of a very large telescope. He finds a variation of only a third of a magnitude and thinks it doubtful if this can be regarded as real. The photographs considered cover the period from 1895 to 1899, and their exposures were from 22^m to $1^h\ 23^m$.

Mr. Stratanoff has also made four long exposures upon this nebula, three of 10^h and one of 20^h duration. These long exposures make the relative magnitude of the central star less, as compared with the stars outside the nebula, than do the short exposures. Mr. Stratanoff suggests that this may be accounted for by supposing the central star to be nebulous, giving upon the plates an image whose intensity increases more slowly than does that of a star proper. He says also that his plates show the contour of this star to be irregular and filamentous, thus differing from the other stars.

Uniformity of Mathematical Symbols.—Professor A. E. Haynes, of the University of Minnesota, has prepared a brief but thoughtful paper recently on the desirability of uniformity in the use of mathematical terms and symbols. Although some of the symbols having two meanings have been long in use, and most are well understood by mathematicians generally; for those who begin the study of this ambiguity, Professor Haynes thinks, is a source of needless confusion that might be remedied.

After indicating how this may be done, he gives some examples of this ambiguity in the following illustrations:

"The word 'cancel' is used, frequently in the same work, in the sense of the striking out of equal factors, and the striking out of numerically equal terms with opposite signs.

The symbol 0 (zero) is used to signify an entire absence of number and an infinitesimally small number.

In many works Naperian logarithms are said to be characterized by the modulus unity, while in others such logarithms are called natural logarithms.

Ratio is defined both as the quotient of the antecedent divided by the consequent, and the consequent divided by the antecedent.

The symbol for multiplication ($\times$) is said to mean 'times,' 'multiplied by' and 'into,' some of which meanings are incorrect, if the multiplier must be an abstract number.

The term parameter is used to signify the double ordinate through the focus of a conic section, and, again, as 'an arbitrary constant entering into an equation of a locus, but which is made variable by hypothesis.'

The base of a system of logarithms is symbolized by *e*, as is also the eccentricity of a conic section.

The word 'decimal' is used with two meanings.

Even the word 'sum' is used with a double meaning While in most cases it is used to signify the aggregate, yet it is also employed to indicate the limit of the sum, as is the case in dealing with an infinite, decreasing geometrical progression.

The word 'limit' as defined, generally excludes the number toward which it constantly approaches, but sometimes it does not.

The word 'pole' as used in analytical geometry, and as used in the theory of functions of a complex variable, has entirely different meanings

The word 'equal,' as used in different works on geometry, is applied to figures having the same magnitude and form, or to those having the same magnitude and unlike form.

Quadratic equations, involving both the second and first powers of the unknown quantity, and those involving only the second power of the unknown quantity, each have at least two names.

While the Greek symbol (π) is used to express the ratio between the circumference of a circle and its diameter, and also to signify the product of an infinite series of factors.

Spherical degree as used in geometry is an objectionable term, for it signifies area rather than difference of direction."

With these illustrations as a basis Professor Haynes makes a strong appeal for needed revision in mathematical language.